Hanford Double-Shell Tank Thermal and Seismic Project - Summary of combined thermal and operating loads with seismic analysis

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U.S. Department of Energy Contract DE-AC27-08RV14800

EDT/ECN: ECN-725855 - R0 UC:
Cost Center: Charge Code:
B&R Code: Total Pages: 684

Key Words: DST, Double-Shell Tanks, dynamic response, waste elastic properties, increased fluid level, sludge level, DST comments

Abstract: Revision 1 is being issued to document changes to the anchor bolt evaluation. RPP-RPT-32237 Rev. 1, Hanford Double-Shell Tank Thermal and Seismic Project-Increased Liquid Level Analysis for 241-AP Tank Farms, described changes to the anchor bolt modeling and evaluation which were implemented in response to the independent reviewer's comments. Similar changes have been made in the bounding tank analysis and are documented in RPP-RPT-28968 Rev. 1. The conclusions of the previous releases of this report remain unchanged.

DATE: HANFORD RELEASE ID: 2
STA: 4
JAN 15 2009

JE Bratton — Release Approval
1/14/2009 — Date
Release Stamp

Approved For Public Release

Tank Farm Contractor (TFC) **RECORD OF REVISION**	(1) Document Number: RPP-RPT-28968	Page 1

(2) Title:
Summary of combined thermal and operating loads with seismic analysis

Change Control Record			
(3) Revision	(4) Description of Change – Replace, Add, and Delete Pages	Authorized for Release	
		(5) Resp. Engr. (print/sign/date)	(6) Resp. Mgr. (print/sign/date)
1 RS	Incorporate ECN 725855 Rev 0	T.C. Mackey 1/8/09 T.C. Mackey	D.J. Washenfelder DJ Washenfelder 01/08/09

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September 2008

Prepared for
CH2M HILL Hanford Group, Inc.
in Support of the
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Sponsored by the U.S. Department of Energy
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Executive Summary

This report summarizes the results of the Double-Shell Tank Thermal and Operating Loads Analysis (TOLA) combined with the Seismic Analysis. This combined analysis provides a thorough, defensible, and documented analysis that will become a part of the overall analysis of record for the Hanford double-shell tanks (DSTs).

The bases of the analytical work presented herein are two ANSYS® finite element models that were developed to represent a bounding-case tank. The TOLA model includes the effects of temperature on material properties, creep, concrete cracking, and various waste and annulus pressure-loading conditions. The seismic model considers the interaction of the tanks with the surrounding soil including a range of soil properties, and the effects of the waste contents during a seismic event.

The structural evaluations completed with the representative tank models do not reveal any structural deficiencies with the integrity of the DSTs. The analyses represent 60 years of use, which extends well beyond the current date. In addition, the temperature loads imposed on the model are significantly more severe than any service to date or proposed for the future. Bounding material properties were also selected to provide the most severe combinations.

While the focus of the analyses was a bounding-case tank, it was necessary during various evaluations to conduct tank-specific analyses. The primary tank buckling evaluation was carried out on a tank-specific basis because of the sensitivity to waste height, specific gravity, tank wall thickness, and primary tank vapor space vacuum limit. For this analysis, the occurrence of maximum tank vacuum was classified as a service level C, emergency load condition. The only area of potential concern in the analysis was with the buckling evaluation of the AP tank, which showed the current limit on demand of 12-inch water gauge vacuum to exceed the allowable of 10.4 inches. This determination was based on analysis at the design waste temperature of 350°F and the full 60-year corrosion allowance on the tank wall of 0.060 inch. However, analysis at a more realistic temperature of 250°F or corrosion allowance of 0.025 inch results in an acceptable demand/capacity ratio according to the ASME code criteria. Thus, buckling of the primary tank is judged to be unlikely for the current lack of corrosion in the tanks, and the expectation that the maximum waste temperature will not exceed 210°F.

The reinforced concrete structure was evaluated as specified by the American Concrete Institute (ACI) code requirements for nuclear safety-related structures (ACI-349). The demand was demonstrated to be lower than the capacity at all locations.

The primary tank was evaluated using the American Society of Mechanical Engineers (ASME) Boiler & Pressure Vessel Code, Section III, Division 1, Service Level D capacities for combined seismic plus non-seismic loading as prescribed in Day et al. (1995) and Bandyopadhyay et al. (1995). It was demonstrated that the general primary membrane stress intensity in the primary tank remained below the material yield stress for combined seismic and non-seismic loading using unfactored demands.

Similarly, the combined non-seismic and unfactored seismic demands for local membrane, plus bending as well as local membrane, plus bending, plus thermal loading, remained below the capacities defined by the code. Therefore, the primary tank is acceptable according to the established criteria. The concrete and steel structures are demonstrated to meet the requirements of the International Building Code 2003.

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While the IBC does not explicitly address underground tanks, provision is made within the code to satisfy its requirements by demonstrating compliance with the requirements of the ACI code for concrete structures. Similarly, the IBC references the ASCE code for steel structures, which in turn requires compliance with the ASME B&PV code. Consequently, by demonstrating compliance with the ACI and ASME codes, the DSTs are shown to satisfy the requirements of the IBC.

The potential for stress corrosion cracking (SCC) of the primary tank, particularly the lower knuckle, was assessed. Based on the recent analysis, current testing, and the historical operational record dating back to 1971, it can be concluded that SCC is unlikely if the present operating requirements are maintained.

The concrete-backed steel liner was evaluated to ASME Section III, Division 2 requirements. The liner strain was determined to be below allowable levels for all load cases.

Attachment of the steel liner to the concrete walls is through the use of anchor bolts. In all cases, the anchor bolts were shown to have adequate margin.

Subsequent to the initial publication of this report, an independent review of the Double-Shell Tanks (DST) Thermal and Operating Loads Analysis (TOLA) combined with the Seismic Analysis was conducted by Dr. Robert P. Kennedy of RPK Structural Mechanics Consulting and Dr. Anestis S. Veletsos of Rice University. Revision 0-A was issued to document their review and address their comments. The results of these clarifications and additional analyses do not affect the conclusions of the original report.

The independent review comments are included in Appendix B. Recommendations to address fluid-structure interaction and the seismic analyses are being addressed in RPP-RPT-30807, "Hanford Thermal and Seismic Project – Dytran Benchmark Analysis of Seismically Induced Fluid-Structure Interaction in Flat-Top Tanks." Analyses to determine the effect of the coefficient of friction between the primary tank and concrete dome on the anchor bolts were conducted and are documented in Appendix C and summarized in Appendix B.4. Revisions to the buckling analyses are documented in RPP-RPT-28967 Rev. 1 and are also summarized in Section 6.4 of this report. The conclusions of the original release of this report remain unchanged.

Revision 1 is being issued to document changes to the anchor bolt evaluation. RPP-RPT-32237 Rev. 1 (Deibler et al. 2008) described changes to the anchor bolt modeling and evaluation for the DST Increased Liquid Level Analysis which were implemented in response to the independent reviewer's comments. Similar changes have been made in the bounding tank analyses and are documented herein. Additionally, Appendix G describes an investigation into the effects of waste level and specific gravity on the primary tank stress and the anchor bolt demands. The conclusions of the previous releases of this report remain unchanged.

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1.0 Introduction

As provided in the CH2M HILL Hanford Group, Inc. (CH2M HILL) statement of work to the Pacific Northwest National Laboratory (PNNL) entitled *Double-Shell Tank (DST) Integrity Project - DST Thermal and Seismic Analyses, Revision 2*, the overall scope of this project is to complete an analysis of record of the DST system at Hanford. The analysis was conducted to provide analytical documentation of the DST system's structural integrity and to support programmatic decisions toward the continued operations of these tanks during waste cleanup operations at the Hanford Site. This work will establish a defensible basis for operating specifications for continued use of the double-shell tanks as well as provide an estimate of the remaining DST useful life.

The overall scope of the project is defined by seven activities expected to be completed over a 3-year period. The primary activities are:

- Thermal and Operating Loads Analysis (TOLA)
- Evaluation of Alternative Liquid Levels in the DSTs
- Seismic Analysis
- Minimum Allowable Wall Thickness Analysis
- Buckling Analysis

Reports have been published documenting the Thermal and Operating Loads Analysis (Rinker et al. 2004), the Seismic Analysis (Carpenter et al. 2006), and the Buckling Analysis (Johnson et al. 2006). This report documents the combination of the TOLA results with the seismic results.

1.1 Purpose of the DST Combined Analysis

The purpose of the DST Combined Analysis is to complete the DST analysis that is described in Appendix A of the TOLA report (Rinker et al. 2004). The intent of the work is to provide a thorough, defensible, and documented analysis that will become a part of the overall analysis of record for the DSTs. The thermal and operating loads analysis (Rinker et al. 2004) includes the static loading only. The seismic demand was calculated in a separate analysis (Carpenter et al. 2006). This summary report documents the combination of the static and seismic demands and capacities.

This work was initiated with a technical review of all available printed documents and electronic data files related to the Phase I, II, and III waste tank analyses (Fisher et al. 1994; Scott and Peterson 1995; Appendix A of Rinker et al. 2004). The existing data files have been cataloged as part of this review. The review includes the tank design drawings and construction procedures, previous tank analytical models, material properties, previous analysis load cases, and other available documents that were used in the original analyses. The results of this review, which are documented in Appendix B of the TOLA report (Rinker et al. 2004), were used to establish the current bounding "as-is" condition of the DSTs as contrasted with the model configuration and assumptions used in previous work.

The tank model was analyzed for a set of bounding thermal and operating load cases to complete an updated review of the analysis documented in the Phase III report. The initial structural analysis of the DSTs (primary steel tank and secondary reinforced concrete tank) considered placement of the soil backfill assuming a uniform soil temperature (i.e., free from thermal stress and at zero days of operation). This analysis provides, as a minimum, the resulting baseline stresses, strains, and deformations in the primary steel tank and the secondary reinforced concrete tank. Additional nonlinear time-dependent analyses of the structure were conducted that calculated the effects of heating the tank to the maximum operating temperature, long-term operation at elevated temperatures, and operating temperature cycles. These analyses also account for the degradation of modulus of elasticity, compressive strength, etc., in the concrete with extended exposure to elevated temperatures. The results predict time-dependent creep, cracking, stresses, strains, and deformations for the entire structure.

The seismic analysis considers the interaction of the tank with the surrounding soil, and the effects of the primary tank contents. The DST and the surrounding soil are modeled as a system of finite elements. The depth and width of the soil incorporated into the analysis model are sufficient to obtain appropriately accurate analytical results. The analysis differs from previous analysis of the DSTs in that the soil-structure interaction (SSI) model includes several (nonlinear) contact surfaces in the tank structure, and the contained waste was modeled explicitly in order to capture the fluid-structure interaction behavior between the waste and the primary tank.

It is noted that the calculations address bounding load cases and do not consider conditions that would apply to thermal and operational loadings that might apply to specific tanks. The objective of this work was to perform a baseline/bounding analysis. The load conditions for this bounding analysis are summarized in Table 1-1. The work is documented (including analysis input files) in such a manner to expedite future sensitivity calculation and tank-specific calculations as required by future needs.

Table 1-1. Bounding DST Analysis Load Conditions for Analysis

Design Load	Value	Notes
Design Life	> 50 years	A 60-year design life is used
Maximum Corrosion Rate	1 mil/yr	A total corrosion allowance of 0.060 inch is applied to the specified nominal thicknesses
Soil Cover (8.3 ft for AY/AZ; 7.5 ft for all others)	8.5 ft @ 125 lb/ft^3	Relative to dome apex
Hydrostatic	422 inches @ 1.7 and 2.0 SpG	SpG = 2.0; applies only to tank AP, which was not determined to be the bounding DST structural design
Pressure	-6 or -12 in. wg (water gauge) $\leq P_{primary} \leq$ +60 in. wg	Primary Tank; -12 in. w.g. applies to AP only
	-20 in. wg $\leq P_{annulus} \leq$ +60 in. wg	Annulus; -20 applies to AP and AY-102 only; -6 for all others
	-6 or -12 in. wg $\leq P_{primary} - P_{annulus}$	Differential; -12 in. w.g. applies to AP only
Live Load	40 lb/ft^2	Uniform
	200,000 lb	Concentrated
Thermal	350°F	Maximum bulk temperature of waste
	20°F/day	Waste maximum heatup/cooldown rate
	1/yr	Cyclic rate
Seismic	0.26 g ZPA	Horizontal
	2/3 Horizontal	Vertical

1.2 Impacts of Analyses

There are number of potential impacts of the analyses that were conducted in support of the DST Integrity work; however, the scope of those impacts is the responsibility of DOE and the Tank Farm operations contractor. The results of the analyses may lead to more or less rigid operating specifications and procedures. For example, several of the DSTs have been exposed to higher thermal loads than most of the other DSTs. It may be necessary to limit certain operations for those specific tanks. While for the remaining DSTs, certain limitations that have existed may be lifted allowing for more effective operations while maintaining safety.

1.3 Double-Shell Tank Design

Figure 1-1 is a simplified diagram of a typical DST structure, showing an inner primary tank and a outer secondary tank covered by a reinforced-concrete shell. The primary and secondary tanks are made of carbon steel plate varying from 3/8 to 15/16 inch thick. The top of the concrete dome is 15 inches thick and it becomes thicker toward the wall. The walls are 18 inches thick. The entire tank structure is buried at a depth of 6 to 8 ft, measured from the top of the tank dome (Han 1996). Figure 1-2 shows the configuration in 3-dimensional cross section.

The DSTs were constructed over a period of about 18 years (from 1968 to 1986), with a design life of 20 to 50 years. Table 1-1 summarizes the service date, expected life span, and current age of the 28 Hanford Site DSTs.

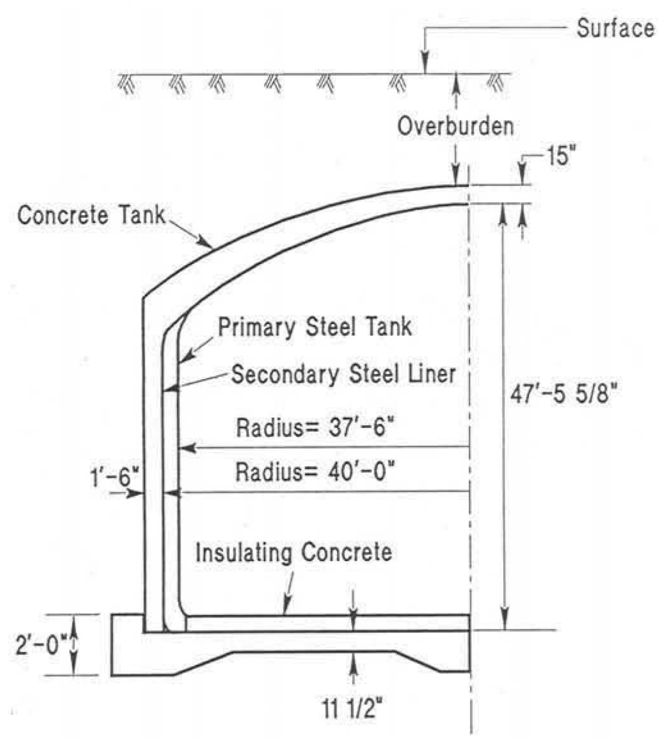


Figure 1-1. Cross Section of a Typical Double-Shell Tank

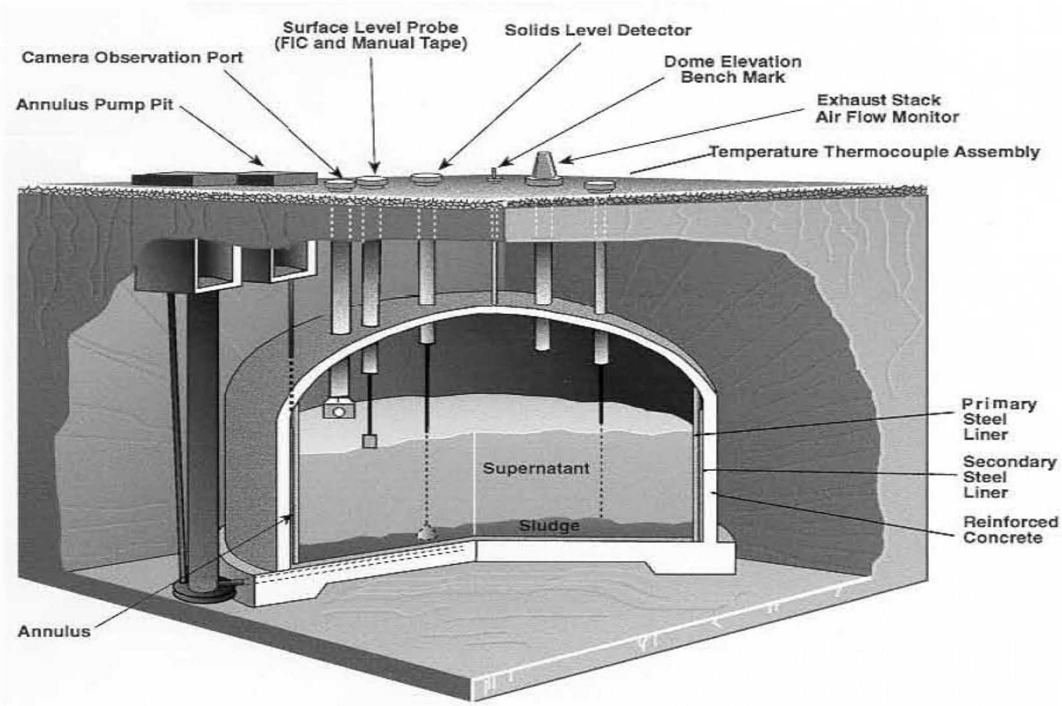


Figure 1-2. Typical Double-Shell Tank Configuration

Table 1-2. Double-Shell Tank Age and Design Life Summary

Tank Farm	Construction Dates	Service Date	Service Life (yr)*	Years in Service
AN (7 tanks)	1980–81	1981	50	23
AP (8 tanks)	1983–86	1986	50	18
AW (6 tanks)	1974–76	1980	50	24
AY (2 tanks)	1968–70	1971	40	33
AZ (2 tanks)	1974–76	1976	20	28
SY (3 tanks)	1974–76	1977	50	27
* Service life is from WHC-SD-TWR-RPT-002, *Structural Integrity and Potential Failure Modes of the Hanford High-Level Waste Tank,* Rev. 0, Westinghouse Hanford Company, Richland, Washington.				

1.3.1 Thermal Characteristics

In recent years the waste in most of the DSTs has been relatively cool, with peak temperatures typically less than 100°F. The waste in the AY and AZ Tank Farm tanks has been somewhat hotter, with recent peak temperatures as high as 186°F (during a mixer pump test in Tank 241-AZ-101). The tanks are cooled primarily by headspace and annulus ventilation, and therefore waste temperatures are somewhat sensitive to the incoming ambient air temperature. The lowest temperatures in the waste typically occur in March, with peak waste temperatures in October. The amplitude of the cycle can be 20 to 30°F. Waste temperatures are decreasing slowly with time in the DSTs because of decay of the radioactive elements that produce the heat load.

The AY and AZ tanks were designed as aging waste facility tanks to handle waste from the Plutonium-Uranium Extraction (PUREX) Facility, with a heat removal capacity of up to 4,000,000 Btu/hr (before recent ventilation modifications reduced this capacity to about 1,000,000 Btu/hr), and with airlift circulators to handle the possible boiling of high-level waste. Tanks such as 241 AY-101 were designed to accommodate a maximum waste temperature of 350°F and historically saw a maximum average of about 247°F. However, reports from 1972 indicate potential localized hot spots as high as 551°F, but with the nearby thermocouples reading less than 300°F. This event was reported in an internal Problem Evaluation Request (PER), and it was determined that there was no impact to tank 241 AY-101 strength or integrity. Currently there is an operational limit of 195°F in the top 15 feet of waste and 215°F below 15 feet. The present temperature of the waste in tank 241 AY-101 is approximately 95°F.

1.3.2 Ventilation System

The annulus ventilation systems for the DSTs are designed to perform three functions: 1) provide primary tank leak detection through continuous radiation monitoring of the annulus exhaust air, 2) limit temperature build-up in the secondary tank concrete, and 3) remove heat and moisture from the annulus space. The primary tank ventilation systems perform similar functions: 1) limit flammable gas accumulation, 2) limit temperature build-up in the primary tank and secondary tank concrete, 3) maintain a vacuum on the primary tank, and 4) remove heat and moisture from the primary tank in order to minimize vapor space corrosion (Duncan 2003). Typical airflow rates in the annulus ventilation system range from a low of 200 ft^3/min to a high of 1075 ft^3/min in tank 241-AY-102 (increased as a special provision for storing the high-heat waste from tank 241-C-106). Typical passive ventilation flow rates are about 10 ft^3/min.

All DSTs have active systems in place for ventilation of the annulus space, but these have not always been maintained in continuous operation. In the AY and AZ Tank Farms, the systems have been available only about 50 percent of the time since tank operations began. The system in the AZ Tank Farm has been off-line for the past 5 years.

Each tank farm has a separate annulus ventilation system. Each exhaust equipment train consists typically of a de-mister, heater, pre-filter, two testable high-efficiency particulate air (HEPA) filters in series, and an exhaust fan. The exhaust fan draws outside air through an inlet damper, a pre-filter, and a high-efficiency filter and distributes it to the annulus through an air-distribution chamber in the concrete pad beneath the primary tank. For tank 241-AY-102, the incoming air is distributed only to the central distribution chamber beneath the center of the primary tank to obtain the maximum amount of cooling from forced convection to the annulus airflow. Tanks 241-AY-101 and 241-AY-102 each have their own annulus exhaust train. Tanks 241-AZ-101 and 241-AZ-102 share a single train.

1.3.3 Primary Tank

The 75-foot-diameter primary steel tank provides containment for the stored waste. The primary tank varies in thickness from a minimum of 3/8 inch in the dome to a maximum of 1 inch at the bottom center of the tank. The primary tank is constructed from a series of formed segmented plates welded in a staggered arrangement. All butt welds on the primary tank received 100% radiographic examination during construction. The tanks were also heated to stress relieve the welds. The primary tank resists the hydrostatic and hydrodynamic waste loads and the internal pressure. The tank is anchored to the concrete dome with steel anchor bolts uniformly spaced at 2 feet in each direction.

1.3.4 Secondary Liner

The secondary steel tank, or liner, lies beneath the insulating concrete and is built directly on top of the concrete foundation. The secondary tanks are about 5 feet larger in diameter than the primary tanks, resulting in a 2.5-foot-wide annular space between the primary and secondary tanks. The secondary liner is joined to the primary tank dome at the upper haunch area, and the two tanks are enclosed in a reinforced concrete shell. The secondary liner provides a second confinement barrier for potential primary tank leaks, thus preventing uncontrolled releases of waste to the environment.

1.3.5 Concrete Shell

On the outside of the secondary tank is a reinforced concrete shell. The exterior concrete shell comprises a foundation, walls, and a dome that completely enclose the secondary tank and primary tank dome. The structural concrete foundations are about 88 feet in diameter and are designed to distribute all weight loads to the ground below. The structural foundation contains drain lines and leak-detection wells to collect any leakage from the secondary liner. The top of the concrete foundation also contains slots to drain any liquid that might leak from the secondary tank.

The concrete shell wall is constructed of steel-reinforced concrete. The shells are about 83 foot in outside diameter and about 18 inches thick and rest on steel slide plates supported by the tank foundation. The concrete shells were poured directly against the secondary liner (i.e., the secondary liner was used as a casting form for the concrete shell). The dome is 15 inches thick and is constructed of steel-reinforced concrete.

Steel riser pipes penetrate the concrete dome and the top of the primary and secondary tanks. The risers provide access to the primary tank and the annulus space for waste transfer operations, equipment installation, and monitoring. The risers are located in covered pits or are located at grade at specific locations above the pits.

1.3.6 Insulating Concrete

The primary tank rests on an 8-inch-thick insulating concrete support pad, located between the primary and secondary tank floors. The concrete pad includes air distribution and drain slots in a grid pattern, which are designed to maintain a uniform tank bottom temperature, to provide a means of heat removal and leak detection, and to help eliminate pockets of water condensation. To provide supplemental cooling, air can be routed through the drain slots via the annulus ventilation system. The drain slots allow any leakage from the primary tank to drain into the annular space, where leak-detection instrumentation is installed.

1.4 Organization of the Combined Loads Summary Report

This report is a continuation of work performed over the past 5 years starting from researching previous structural analyses and related technical documents on the DSTs through the evaluation of the current model that has been generated. The organization and content of this report are described briefly as follows:

- Chapter 1 – Introduction: Provides the background and overall purpose of the Double-Shell Tank Thermal and Seismic Analysis. The scope of the Thermal and Operating Loads and Seismic analyses are described. Basic DST information is also included in this chapter.
- Chapter 2 – TOLA Model: Describes the ANSYS® finite element model used for the thermal and operating loads analyses. Summarizes the material properties, loads and load case combinations.
- Chapter 3 – Seismic Model: Describes the ANSYS® finite element model used for the seismic analyses. Summarizes the material properties, boundary conditions and acceleration time-histories.
- Chapter 4 – Model Reconciliation: Discusses the differences between the TOLA and seismic models and the methods for combining results.
- Chapter 5 – Structural Acceptance Criteria: Describes the code-based acceptance criteria used to evaluate the combined results.
- Chapter 6 – Analysis Results: Provides a summary of the combined TOLA + seismic results. The ACI concrete evaluation for each run is presented and followed by the ASME primary tank evaluation. The stress-corrosion cracking criteria for the primary tank are considered next, followed by buckling analyses of the primary tank. Finally, the ASME evaluation of anchor bolts and the secondary liner are assessed.
- Chapter 7 – Conclusions and Recommendations: Summarizes the thermal and operating loads analysis with conclusions regarding DST structural integrity based on the evaluations conducted.
- Appendix A – Seismic Model Primary Tank Knuckle Stress Evaluation: Provides details of an evaluation of mesh size sensitivity in the knuckle region of the primary tank.
- Appendix B – Reviewer Comments and Discussion: Documents reviewers comments from May 2006.
- Appendix C – Dome Friction Study: Describes dome friction study conducted in response to reviewer comments.
- Appendix D – Anchor Bolt Modeling and Evaluation: Documents changes to the anchor bolt modeling and evaluation in response to reviewer comments.
- Appendix E – ANSYS Model Files: Documents the ANSYS model input and post-processing files that have not been documented elsewhere.
- Appendix F – ANSYS Validation and Verification: Provides the data related to ANSYS verification problems and validation of the results of the computer runs.
- Appendix G – Waste Level and Specific Gravity Investigation: Describes investigation into the effects of waste depth and specific gravity on primary tank stress and anchor bolt demand.

2.0 TOLA Model

2.1 Introduction

This chapter describes the ANSYS® finite element (FE) model, material properties, loads used for the double-shell tank (DST) Thermal and Operating Loads Analysis (TOLA). Complete documentation of the model is found in the TOLA report (Rinker et al. 2004). The current report contains summaries of the model, material properties and loads. The TOLA report should be referenced for complete model description and background information.

2.2 241-AY Finite Element Model

This section describes the geometry and construction of the ANSYS® finite element model. A comprehensive description of the FE model is found in the TOLA report (Rinker et al. 2004). The TOLA report should be referenced for complete model description and background information.

2.2.1 241-AY Tank Model Geometry

The TOLA report provided the rationale for choosing the 241-AY tank as the basis for the bounding model for the DST analyses. The geometry for this tank was taken from the design drawings listed in Table 2-1. A limited number of construction drawings, relating primarily to the steel tank construction, also were referred to for confirmation of dimensions.

It was helpful to review the other tank drawings, particularly 241-SY, because of its similarity to the 241-AY tank. In addition, the newer tank drawings, such as 241-AP, provided valuable insight to the reinforcing steel details.

Table 2-1. Double-Shell Tank 241-AY Design Drawings

Drawing #	Title
H-2-64306	Tank foundation plan
H-2-64307	Structural insulating concrete plan and details
H-2-64310	Concrete tank section and details
H-2-64311	Concrete dome reinforcement plan & details
H-2-64449	Tank elevation & details

2.2.2 ANSYS® Model Construction

ANSYS® Version 7.0 was used in all the analyses. The FE model was developed using ANSYS® APDL macros that build the geometry in 2-D and sweep the cross section about the tank central axis. The macros are listed in Appendix C and also are available electronically. A 2.9-degree section of the tank was modeled with symmetry boundary conditions. This gives an element length of 24 inches in the circumferential direction at the concrete tank inside diameter, which is equal to the anchor bolt spacing. Figures 2-1 through 2-4 show various aspects of the model.

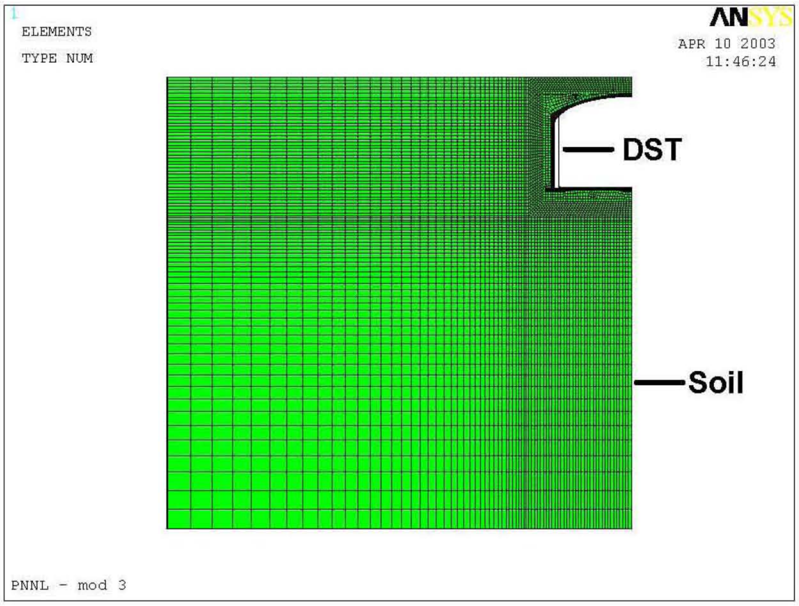


Figure 2-1. Finite Element Mesh of Full Model

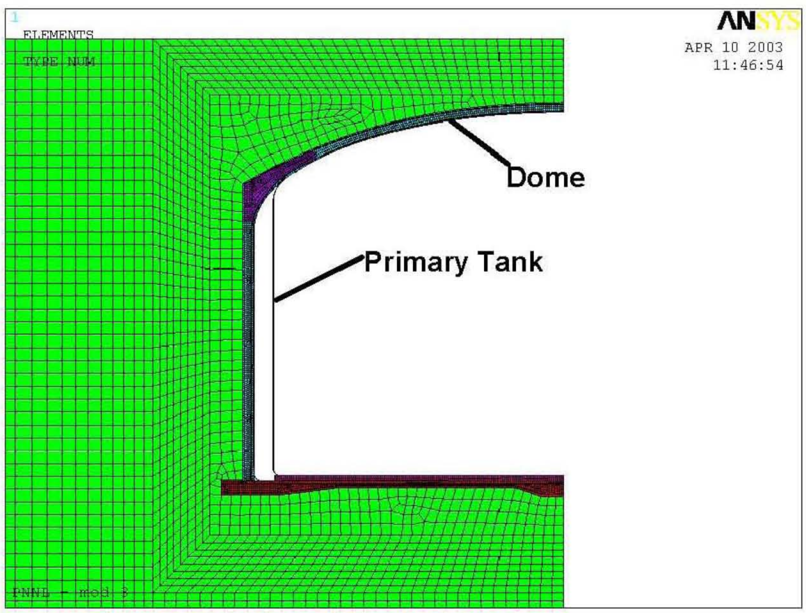


Figure 2-2. Close-up Showing Finite Element Mesh of Tank

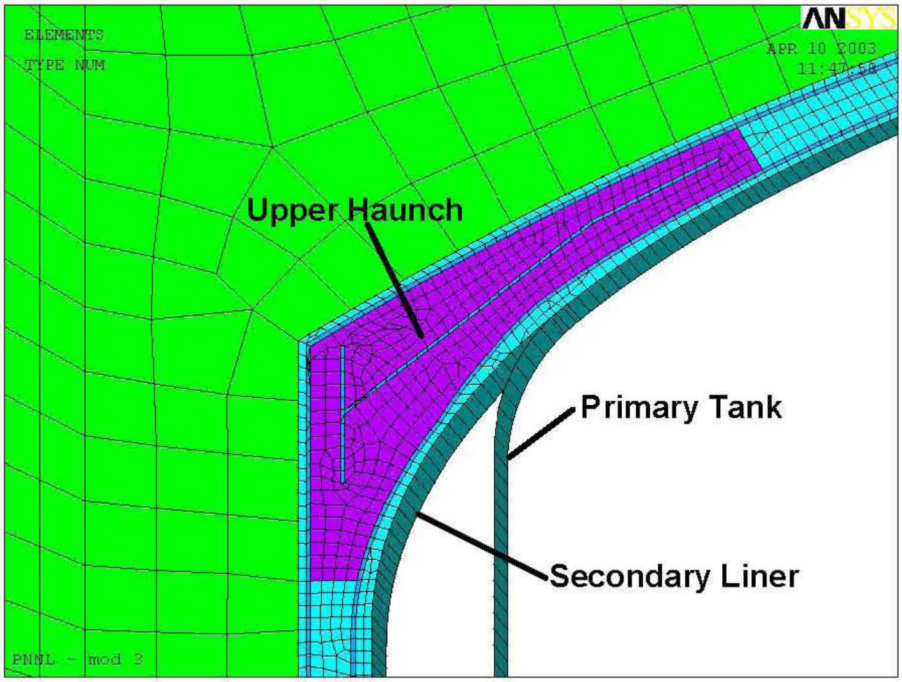


Figure 2-3. Close-up Showing Mesh of Haunch

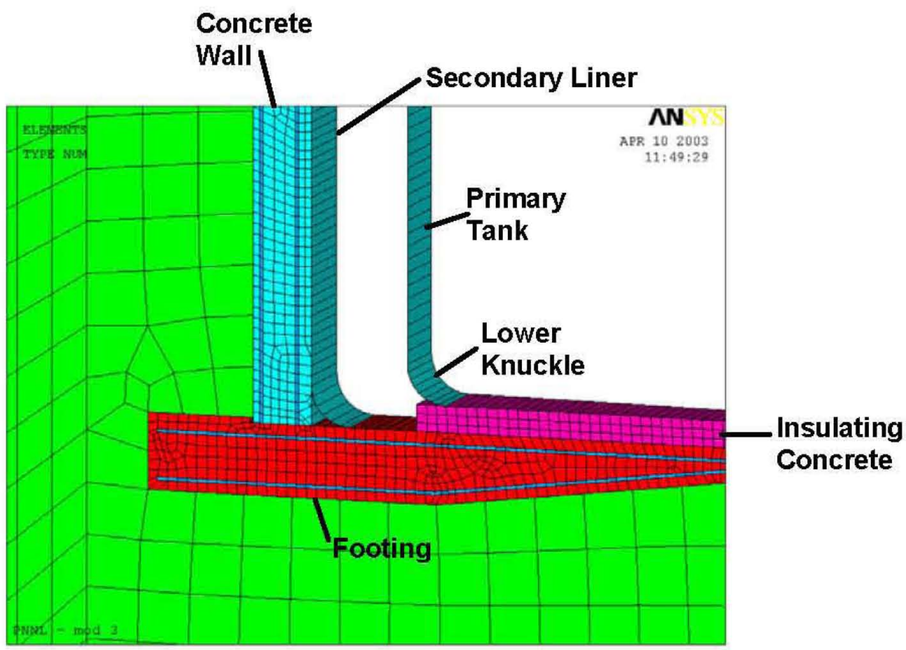


Figure 2-4. Close-up Showing Mesh of Tank Base

The model was constructed with a nominal soil overburden of 8.3 feet. The subgrade undisturbed soil depth is specified at 168 feet below the foundation. The lateral soil dimension is 240 feet and includes a "stair step" boundary to distinguish between undisturbed soil and compacted backfill.

SOLID65 elements are used to represent the reinforced concrete regions. The tank liners, insulating concrete confinement ring, liner construction stiffeners, and the anchors use SHELL181 elements with full integration. The anchor bolts were represented with BEAM4 elements in the original models. These were replaced with COMBIN40 springs in the reanalysis of the anchor bolts in Rev. 1. Nonlinear contacts between various surfaces use the TARGET170 and CONTACT173 elements. SOLID45 elements are used to explicitly represent the soil.

The reinforced concrete is divided into regions that have different steel reinforcement ratios, where it is assumed that the thickness of each rebar layer is 1 inch. The rebar capabilities of the SOLID65 concrete elements were used to represent the reinforcing steel. For regions with nonzero reinforcement ratios, the element attributes include an element coordinate system and two rotation angles that identify the rebar orientation. The element x-axis is parallel to the radial direction, the y-axis is parallel to the circumferential direction, and the z-axis is parallel to the vertical direction. The dome uses the z-axis for the vertical/radial direction. The haunch region uses a spherical coordinate system to define the local x-direction (radially outward from the global origin at the bottom/center of the primary tank) to represent the diagonal ties. Note that the directions used for the rebar's three volume ratios specified as real constants are not in the element coordinate system x-, y-, or z-directions (ESYS), but rather the element x-direction for x, rotation angle theta for y, and rotation angle phi for z. See the ANSYS® Elements Manual and Theory Manual for SOLID65 for more detail.

The ANSYS® concrete material model has no provision for representing the post-cracking tension stiffening behavior of reinforced concrete. The stiffness of an element becomes zero immediately upon cracking. As a consequence, achieving convergence proved nearly impossible during the large-scale cracking that occurs in the model during a thermal cycle. Previous DST analytical reports describe similar difficulties and relate the use of "glue elements" to stabilize the solution. For this analysis, a set of SOLID45 elements was superimposed over the SOLID65 concrete elements to provide numerical stability to the model. These elements were assigned a low modulus (approximately 0.5% of the nominal concrete modulus). The use of these augmented stiffness elements greatly facilitated the model convergence and was demonstrated to have no significant impact on the resulting forces, moments, stress, or strain.

The program flow for the model, including a brief description of each macro, is as follows:

SET_SLICE.MAC

- **PNNLA.MAC** – basic tank parameters and 2-D geometry, no soil geometry. Geometry divided to accommodate rebar, anchor bolts, and construction stiffeners later. Many area components created.
  - **SET_PARMS** – sets model parameters that may change (e.g., loads, material properties, overburden depth)
- **PNNLA2.MAC** – element attribute (real, type, mat, esys) assignments (not values) to geometry (not soil)
  - **SET_RX.MAC** – selects areas within a range of x
  - **SET_REAL.MAC** – assigns real constant attribute to each area
  - **SET_RY.MAC** – selects areas within a range of y
  - **SET_REAL.MAC** – assigns real constant attribute to each area

  - **SET_REAL.MAC** – assigns real constant attribute to each area

- **PNNLA3.MAC** – identify as components: anchor bolt lines (line_bolt), stiffener lines (line_stiff), anchor lines (line_anch in haunch), primary tank lines (line_prim), secondary liner lines (line_secon), bottom anchor lines (line_botanch)

- **PNNLA4.MAC** – 2-D soil geometry, 2-D mesh of soil and the other 2-D solids, rotate to create 3-D geometry/mesh for slice model (no 3-D shell elements), note that soil geometry/mesh is later redefined in set_soil.mac
  - **MESH_SIZE.MAC** – sets default element size for rebar and soil elements, sets sweep angle, and sets number of divisions per quadrant

- **PNNLA5.MAC** – merges nodes/keypoints at slab/rebar and tank/rebar; couples all soil nodes to corresponding structural nodes and top of slab to bottom of wall and top of slab to bottom of insulating concrete (note that all coupling is later deleted)

- **PNNLA6.MAC** – generates anchor bolts, studs, wall base plate, confining ring below secondary liner, confining ring for insulating concrete, wall, and dome stiffeners.

- **PNNLA7.MAC** – generate primary tank geometry and mesh, define values for all tank real constants, couple vertical displacements at liner bottom

- **PNNLA8.MAC** – generates secondary liner geometry and mesh, couples vertical displacements at liner bottom, couples shell horizontal displacements to sidewall, couples shell vertical displacements to dome, merges secondary liner nodes with slab top nodes

- **PNNLA9.MAC** – merges liner to anchor bolts/studs/anchor nodes, applies constraints
  - **SET_MATERIALS.MAC** – sets all material properties
  - **SET_OPTIONS.MAC** – includes/excludes certain nonlinear material models (e.g., nonlinear concrete, creep, nonlinear steel liner, nonlinear rebar, nonlinear soil)
  - **SET_SOIL.MAC** – creates soil geometry and mesh; couples to concrete

- Delete all coupled sets

- **SET_AREAS_SLICE.MAC** – defines area components for contact definition

- Add steel plate below wall (on slab)

- Add nonlinear contact with appropriate friction coefficients per Section 3.6.2 between soil/concrete, secondary liner/concrete wall, primary tank/dome, primary tank/insulating concrete, slab top/insulating concrete, and wall/slab

- Merge insulating concrete bottom/secondary liner nodes, liner/concrete nodes at centerline

- **SET_ESYS_3D.MAC** – define all rebar elements real, modify secondary liner elements above 357.5 inch to be 3/8 inch thick

- **APPLY_LOADS_SLICE.MAC** – reverse area normal of radiused section of secondary liner, apply parametric loads
  - **MESH_SIZE.MAC** – sets default element size for rebar and soil elements, sets sweep angle, and sets number of divisions per quadrant
- Apply axisymmetric boundary conditions
- Copy anchor bolts, etc. for slice model; divide anchors by 2 for slice model
- Couple nodes at primary/secondary liner intersection
- Define soil layers including elevation and material properties
  - **SET_SLAYER.MAC** – applies soil material properties to a layer
- **SET_BACKFILL.MAC** – defines backfill region and sets linear and nonlinear material properties
- Define augmented stiffness elements
- Merge duplicate contact elements/nodes
- Apply gravity, waste depth, surface loads, annulus and primary tank pressures
- **SET_SLICEB.INP** runs the thermal cycling for years 1 and 2
- **SET_SLICEC.INP** runs the thermal cycling for years 3 through 5
- **SET_SLICEF.INP** runs the thermal cycling and creep for years 6 through 60
- **SET_SLICEG.INP** runs the thermal cycling for year 61
- **SET_SLICEF1.INP** runs the 400 kips live load case
- **SET_SLICEF1LF.INP** runs ACI load combination 1 for the 400 kips live load case
- **SET_SLICEI.INP** runs ACI load combination 9' for either the 400 or 1800 kips live load case
- **SET_SLICEF9.INP** runs the 1800 kips live load case
- **SET_SLICEF9LF.INP** runs ACI load combination 1 for the 1800 kips live load case
- **SET_SLICE10A.INP** runs the maximum live load case to determine the limit concentrated load for the DST.

The ANSYS® concrete material model is used for the SOLID65 elements. This allows for cracking and crushing, as well as variable shear transfer for open/closed cracks. In addition, the implicit creep material model for concrete was used. ANSYS® allows for the concrete cracking/crushing material model and creep material model to be used simultaneously.

The soil elements use the Drucker-Prager constitutive model, which has an internal friction angle, cohesion, and a dilatancy angle as material properties (see Chapter 2.3.5). A small positive value of cohesion is used to represent the Hanford cohesionless soils, and the dilatancy angle is assumed to be equal to the friction angle (this parameter induces volume changes as a function of element shear stress).

The soil region surrounding the concrete tank and foundation is coupled to the concrete using nonlinear surface-to-surface contact elements, where the sliding friction coefficient is as specified in Chapter 2.3.6.

The tank liners are coupled to the structural and nonstructural concrete in a similar manner, i.e., with nonlinear contact elements. A friction coefficient is used for these surfaces as well, as specified in Chapter 2.3.6, these include contact between the following surfaces:

- secondary liner and tank
- primary tank and dome
- bottom of primary tank and top of insulating concrete
- top of slab and bottom of insulating concrete
- bottom of secondary liner and top of slab
- bottom of tank wall and top of slab.

2.2.3 Real Constants

ANSYS® uses real constants to define element properties for certain element types, e.g., thickness for shell elements. The thicknesses of the different regions of the steel liners are defined in **SET_PARMS.MAC** and assigned in **PNNLA7.MAC**. The thickness of the primary tank that is in contact with the waste was given a 0.001 inch/year corrosion allowance for the desired 60 year design life for a total reduction of 0.060 inch at the beginning of the analysis. Real constants for the wall and dome stiffeners are defined in **PNNLA6.MAC**.

2.2.3.1 Reinforcing Steel

The concrete reinforcing steel is modeled by using the rebar capabilities of the ANSYS® SOLID65 element. Elements of 1-inch thickness were defined in the appropriate locations in the dome, haunch, wall, and foundation. The real constants for the rebar elements include the following for each of three possible rebar directions:

- the rebar material ID
- steel volume ratio
- two angles used to orient the rebar directions relative to the element coordinate system.

Tables 2-2 through 2-5 show the calculations for the steel volume ratios required for the concrete rebar elements. The geometry of the rebar, including the locations of transition between rebar volumes, is defined in **PNNLA.MAC**. Real constants are initially assigned by location in **PNNLA2.MAC**. The volume ratios and rebar orientation are defined in **SET_ESYS_3D.MAC**.

Table 2-2. Foundation Concrete Rebar Volume Ratios

Description:	Slab Bottom								
Elevation (in.)	Radius (in.)	Bar Size	*Meridional* Spacing[(a)]	# Bars[(a)]	Volume Ratio	Bar Size	*Hoop* Spacing	Volume Ratio	Real Constant
NA	75	5	12	NA	0.0256	5	12	0.0256	101
	115	5	NA	48	0.0258	5	12	0.0256	102
	202	5	NA	95	0.0316	5	12	0.0256	103
	350	5	NA	189	0.0360	5	12	0.0256	104
	369	5	NA	240	0.0326	5	12	0.0256	105
	435	5	NA	240	0.0293	5	12	0.0256	106
	444	5	NA	240	0.0267	6	8	0.0552	107
	528	7	NA	512	0.1016	6	8	0.0552	108
Description:	**Slab Top**								
Elevation (in.)	**Radius (in.)**	**Bar Size**	***Meridional* Spacing**	**# Bars**	**Volume Ratio**	**Bar Size**	***Hoop* Spacing**	**Volume Ratio**	**Real Constant**
NA	75	5	12	NA	0.0256	5	12	0.0256	111
	115	5	NA	45	0.0242	5	12	0.0256	112
	202	5	NA	99	0.0330	5	12	0.0256	113
	350	5	NA	198	0.0377	5	12	0.0256	114
	369	5	NA	198	0.0269	5	12	0.0256	115
	435	5	NA	256	0.0313	5	12	0.0256	116
	444	5	NA	256	0.0284	6	8	0.0552	117
	528	5	NA	256	0.0259	6	8	0.0552	118

(a) The drawings used to obtain this information specify rebar by spacing or # bars; therefore, where a measurement for Meridional spacing is given, information for # bars is not recorded, and vice versa.
NA = not applicable.

Table 2-3. Wall Concrete Rebar Volume Ratios

Description:	Wall								
Elevation (in.)	Radius (in.)	Bar Size	*Meridional* Spacing[(a)]	# Bars[(a)]	Volume Ratio	Bar Size	*Hoop* Spacing	Volume Ratio	Real Constant
147	75	6	12	NA	0.0368	8	8	0.0982	201/206
204	115	6	9	NA	0.0491	8	8	0.0982	202/207
303	202	6	9	NA	0.0491	8	12	0.0654	203/208
339.5	350	8	12	NA	0.0654	8	12	0.0654	204/209
381.5	369	8	12	NA	0.0654	8	12	0.0654	205/210

(a) The drawings used to obtain this information specify rebar by spacing or # bars; therefore, where a measurement for Meridional spacing is given, information for # bars is not recorded, and vice versa.
NA = not applicable.

Table 2-4. Dome Concrete Rebar Volume Ratios

Description: Elevation (in.)	Dome Radius (in.)	Bar Size	*Meridional* Spacing[(a)]	# Bars[(a)]	Volume Ratio	Bar Size	*Hoop* Spacing	Volume Ratio	Real Constant
NA	120	6	NA	51	0.0453	6	12	0.0368	301
	183	6	NA	101	0.0490	6	12	0.0368	302
	270	6	NA	202	0.0651	6	12	0.0368	303
	304.5	6	NA	202	0.0496	8	6	0.1309	304
	314	8	NA	346	0.1399	8	6	0.1309	305
	354	8	NA	346	0.1300	9	6	0.1657	306
	368.9	8	NA	346	0.1197	9	4	0.2485	307
	391	8	NA	346	0.1139	9	4	0.2485	308

(a) The drawings used to obtain this information specify rebar by spacing or # bars; therefore, where a measurement for Meridional spacing is given, information for # bars is not recorded, and vice versa.
NA = not applicable.

Table 2-5. Haunch Concrete Rebar Volume Ratios

Elevation (in.)	Haunch External Radius (in.)	Bar Size	*Meridional* Spacing[(a)]	# Bars[(a)]	Volume Ratio	Bar Size	*Hoop* Spacing	Volume Ratio	Real Constant
NA	450	8	NA	519	0.1534	9	4.5	0.2209	401
NA	496	8	NA	519	0.1375	9	4.5	0.2209	402
NA	496	8	4	NA					
408	NA	6	6	NA	0.2700	8	6	0.1309	404
452	NA	8	6	NA	0.1309	9	4	0.2485	403
Elevation (in.)	**Internal Radius (in.)**	**Bar Size**	***Meridional* Spacing[(a)]**	**# Bars[(a)]**	**Volume Ratio**	**Bar Size**	***Hoop* Spacing**	**Volume Ratio**	**Real Constant**
NA	480	8	NA	519	0.1489	9	4.5	0.2209	406
408	NA	8	6	NA	0.1309	8	6	0.1309	405
Elevation (in.)	**Middle Radius (in.)**	**Bar Size**	***Meridional* Spacing[(a)]**	**# Bars[(a)]**	**Volume Ratio**	**Bar Size**	***Hoop* Spacing**	**Volume Ratio**	**Real Constant**
NA	486.5	6	NA	163	0.0261	9	4.5	0.2209	502
435	487	6	NA	163	0.0235	9	8	0.1243	500
451	NA	4	18	NA	0.0109	9	8	0.1243	501
	Ties	**Bar Size**	***Meridional* Spacing**	**Hoop Space**	**Volume Ratio**				
NA		4	16	18	0.0007	NA	NA	NA	NA

(a) The drawings used to obtain this information specify rebar by spacing or # bars; therefore, where a measurement for Meridional spacing is given, information for # bars is not recorded, and vice versa.
NA = not applicable.

2.2.3.2 Anchor bolts

The tank design drawings listed in Table 2-1 specify an anchor bolt spacing of 2 feet by 2 feet. The 3-D finite element model was constructed as a 2.9-degree wedge which gives the correct 24-inch spacing at the concrete wall (480 feet). The derivation of the axial and shear spring stiffness used in the Rev. 1 anchor bolt reanalysis is described in Appendix D. Three cases were considered: lower bound – 47 kips/inch, upper bound – 90 kips/inch and fully cracked – 23.5 kips/inch. The individual anchor bolt stiffness was adjusted based on the radial location to account for the anchor bolt spacing.

2.3 Material Properties

This section summarizes the material properties used in the TOLA finite element model. A comprehensive description of the structural and thermal properties is found in the TOLA report (Rinker et al. 2004). The TOLA report should be referenced for complete material property description and background information.

2.3.1 Structural Concrete

This section summarizes the structural properties of reinforced concrete that were used in the finite element analysis. The concrete properties listed here represent Hanford batch concrete with a 3-ksi specified minimum compressive strength, as specified for the 241-AY tank design. The properties are summarized in figures and tables in this section.

The concrete elastic modulus was prescribed to be temperature-dependent, as shown in Figure 2-5. The concrete compressive and tensile strengths are shown in Figure 2-6. These are the mean strengths as described in the TOLA report (Rinker et al. 2004). These values are used in the ANSYS® cracking algorithm employed with the SOLID65 concrete elements. The crushing capabilities of the SOLID65 elements were not used in the finite element analysis to confirm adequate margins at 400 kips concentrated load. The ACI code evaluation (see Chapter 6.1) used the lower bound compressive strengths to determine the load and moment capacities of the reinforced concrete tank structure. Thus the analysis conservatively used the mean strength properties to determine the demand and the lower bound properties to establish the concrete section capacity. The TOLA report (Rinker et al. 2004) describes the basis for the concrete strength degradation as a function of temperature.

The secondary goal of this analysis was to determine the nonlinear load-displacement response of tank dome to predict the dome displacement that would be indicative of impending dome collapse. In order to accomplish this task, it was necessary to use the crushing feature of the SOLID65 concrete elements in the dome. Accordingly, the crushing was enabled in the dome elements and the compressive strengths and their distribution in the dome are as specified in Figure 2-7.

The coefficient of thermal expansion (CTE) of concrete was taken to be 0.37 x 10^{-6} in./in./F. Poisson's ratio was specified to be 0.15.

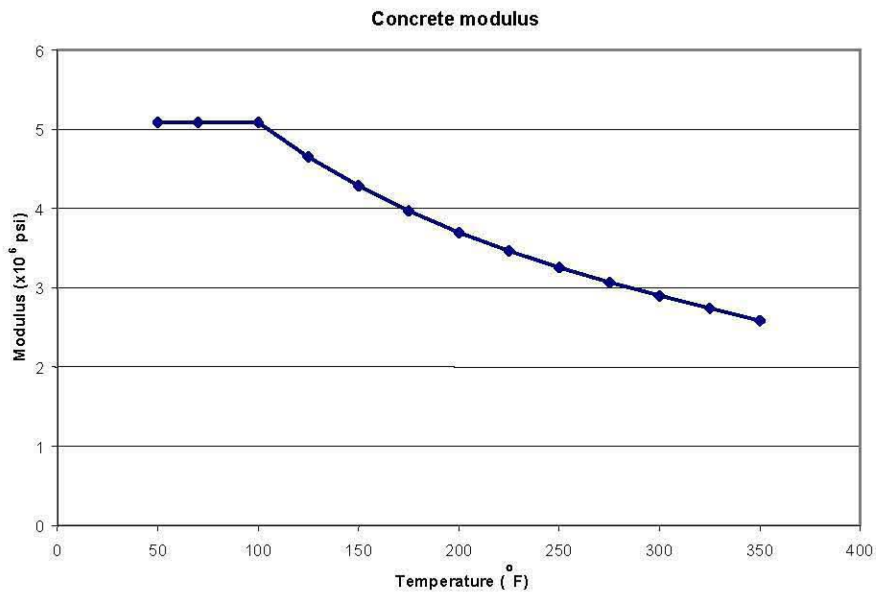


Figure 2-5. Concrete Elastic Modulus

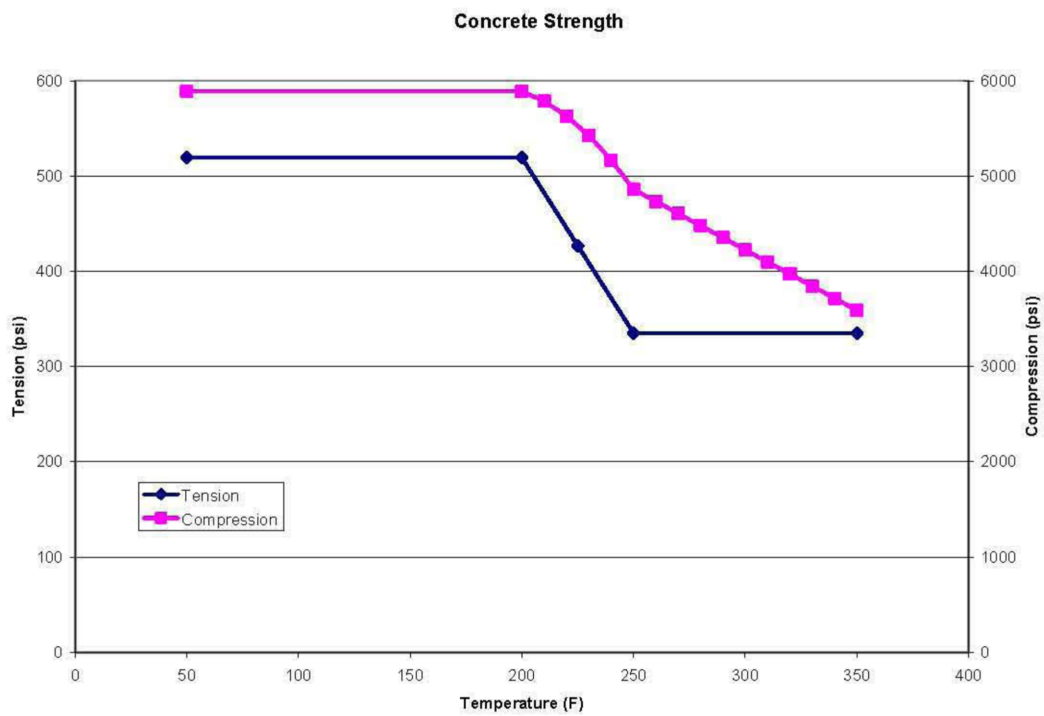


Figure 2-6. Concrete Strength Used for Finite Element Analysis

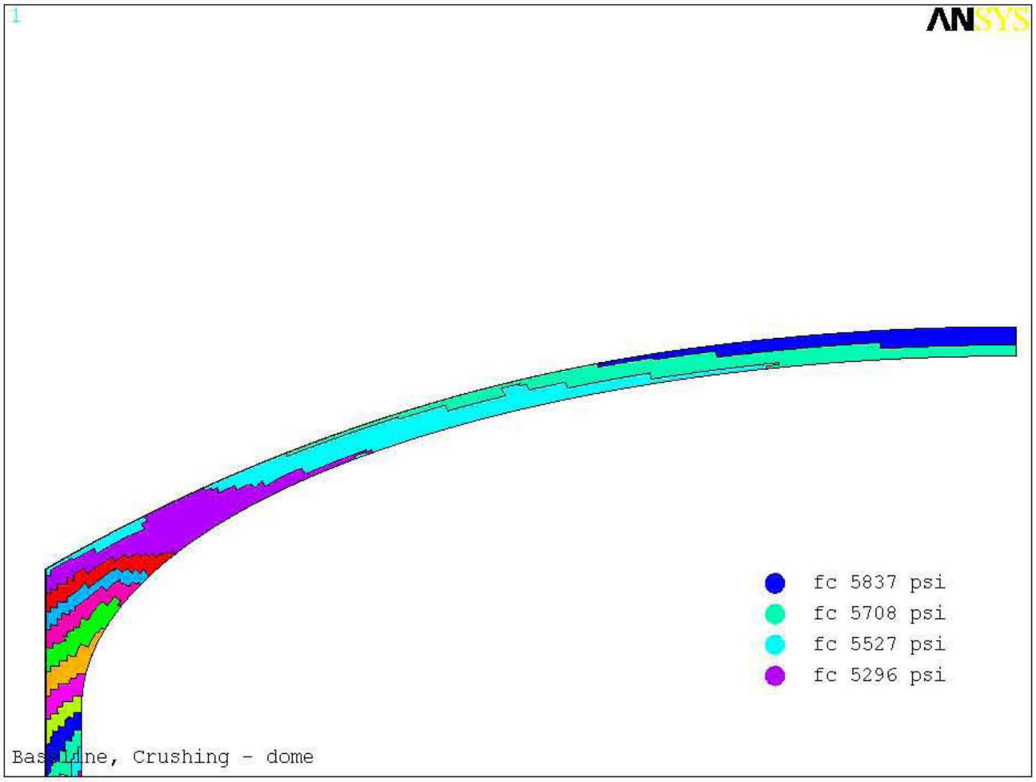


Figure 2-7. Dome Concrete Compressive Strength Distribution

Previous DST analyses have identified concrete creep as being an important material parameter. The TOLA report (Rinker et al. 2004) describes the procedure and data used for defining the concrete creep material model. The time-hardening creep algorithm in ANSYS® is defined as

$$\dot{\varepsilon}_{cr} = C_1 \sigma^{C_2} t^{C_3} e^{-C_4/T} \tag{1.1}$$

The coefficients used for the ANSYS® time-hardening implicit creep law are given in Table 2-6. The creep law parameters are provided to ANSYS® via the TBDATA command found in **SET_PARMS.MAC**.

Table 2-6. Coefficients for the ANSYS® Creep Law

Coeffic.	Value
C1	0.2545×10^{-6}
C2	1
C3	-0.838
C4	320

2.3.1.1 Degraded Concrete Properties

It was necessary to establish a procedure to prevent the concrete modulus and strength from "recovering" during subsequent thermal cycles after the initial degradation due to elevated temperature. This was accomplished by redefining the concrete material properties in their degraded condition at the end of the first year at 350°F. Because the degradation is temperature dependent, this required segregating the concrete elements into groups of 10-degree increments based on their maximum temperature (steady-state). A modified set of concrete properties in the degraded condition was defined. At the conclusion of the first year of creep, the properties of each 10-degree group of concrete elements were changed using the ANSYS® mpch command to redefine these elements with the degraded properties.

2.3.2 Insulating Concrete

A linear elastic material model was prescribed for the insulating concrete. Table 2-7 lists the structural properties that were used. The compressive strength was not used in the finite element analysis but was employed in the evaluation of the insulating concrete stress level.

Table 2-7. Structural Properties for the Insulating Concrete

Material Property	**Units**	**Value – Tank AY**
Compressive Strength	psi	200
Elastic Modulus	psi	165,000
Poisson's Ratio		0.15
Density	lbf/ft^3	50
Coefficient of Thermal Expansion	in/in-°F	3.7

2.3.3 Structural Steel

The elastic modulus of the primary tank and the secondary liner structural steels was defined to be temperature-dependent, as shown in Figure 2-8. An elastoplastic material model was defined with a yield of 36000 psi and a tangent modulus of 1% the nominal elastic modulus. The density of steel was taken as 490 lb/ft^3. Poisson's ratio was taken as 0.30. The steel CTE was defined to be temperature dependent as shown in Figure 2-9.

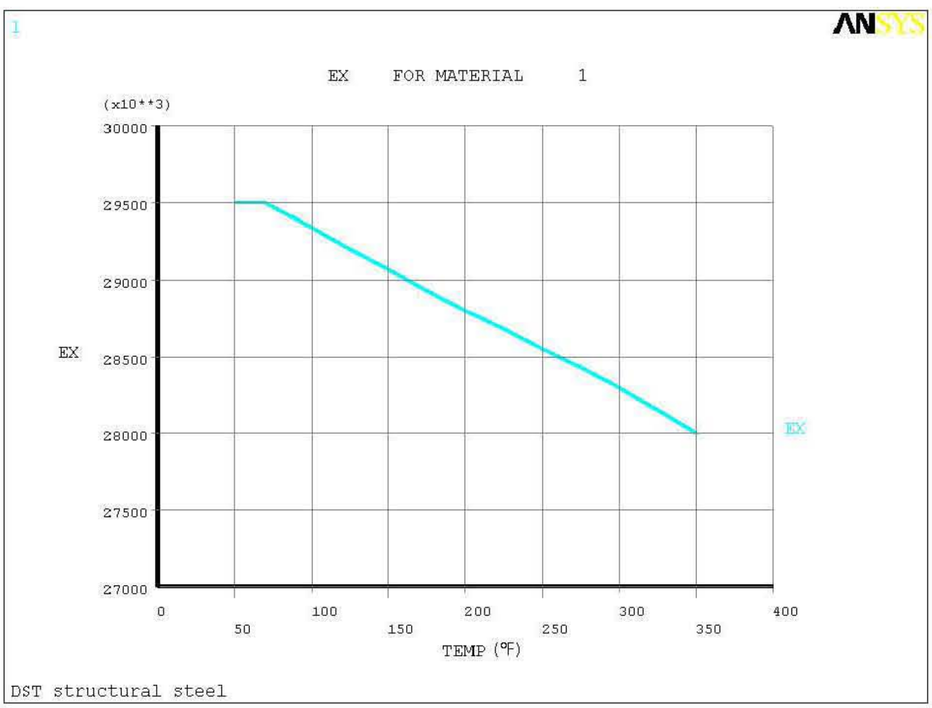


Figure 2-8. Structural Steel Elastic Modulus

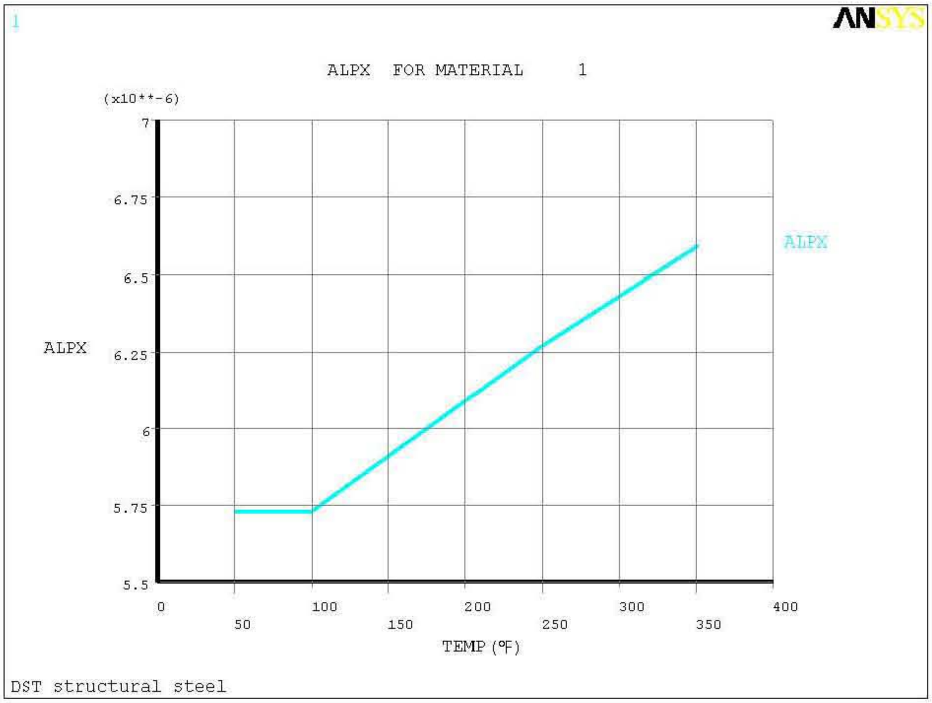
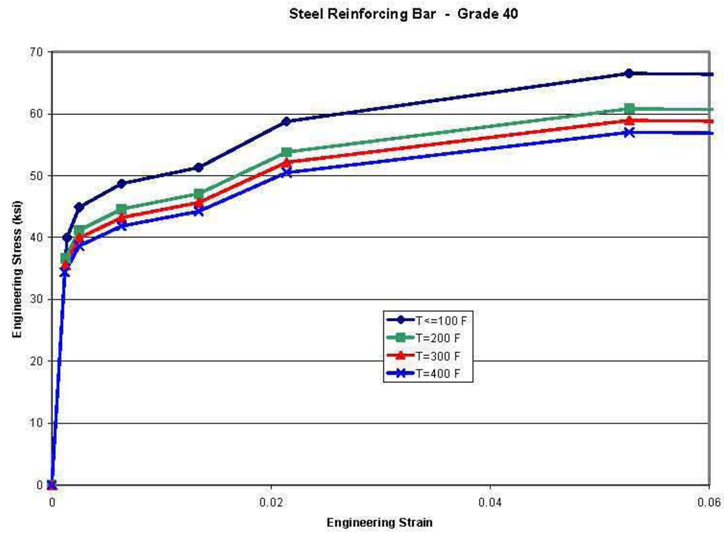


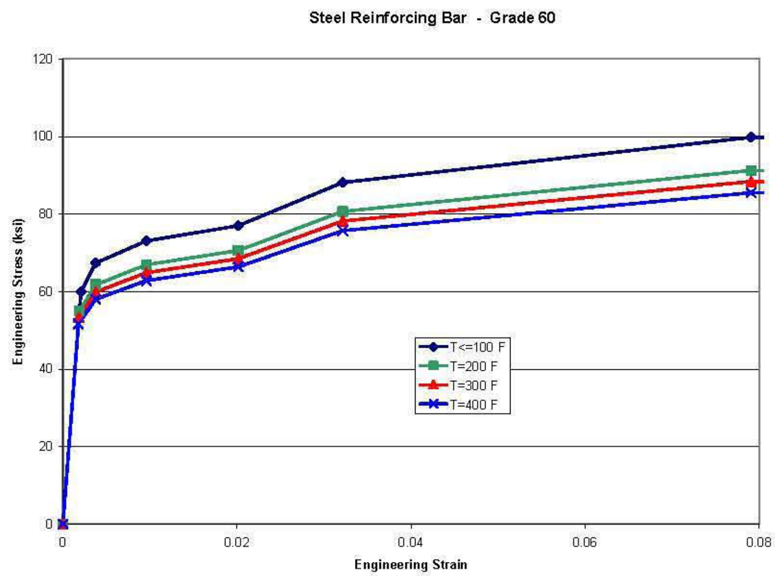
Figure 2-9. Structural Steel Coefficient of Thermal Expansion

2.3.4 Reinforcing Steel

Two grades of reinforcing steel were used in the construction of the 241-AY DST. Rebar with 40,000 psi yield strength was used in the slab, and steel with 60,000 psi yield strength was used in the wall and dome. The nonlinear stress-strain curves shown in Figure 2-10 for both grades of rebar were implemented in the ANSYS® model. The density was specified to be 490 lb/ft^3. Poisson's ratio was taken as 0.3 and the mean CTE was specified as 6 x 10^{-6} in./in.-°F.



(a)



(b)

Figure 2-10. Steel Reinforcing Bar Stress-Strain Curves: a) Grade 40 rebar (slab), b) Grade 60 rebar (wall and dome)

2.3.5 Soils

Distinction was made between the undisturbed soil and the compacted backfill, as shown Figure 2-11. The DST foundation is supported by the undisturbed native soil. The backfill applies radial pressure and axial frictional force to the tank walls and a dead load to the dome. The FE soil properties were distributed accordingly, as depicted in Figure 2-12.

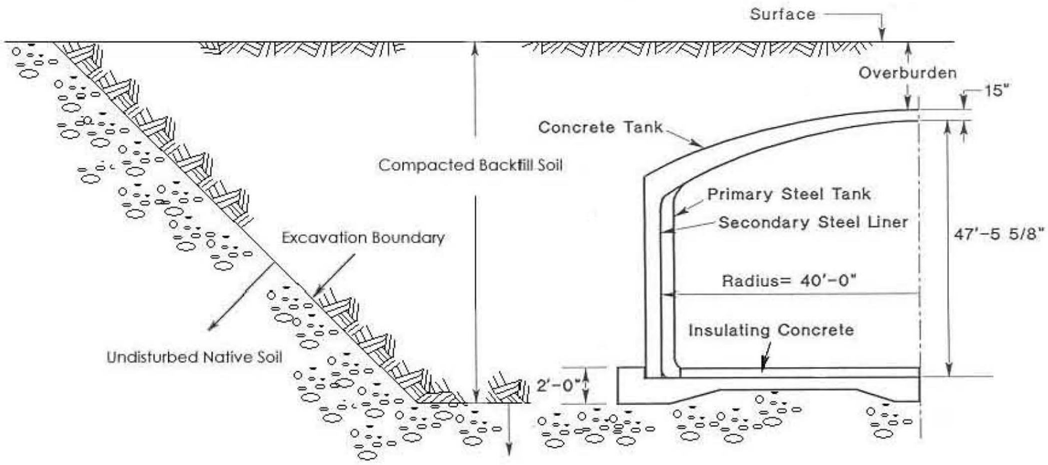


Figure 2-11. Soil Configuration Adjacent to DSTs

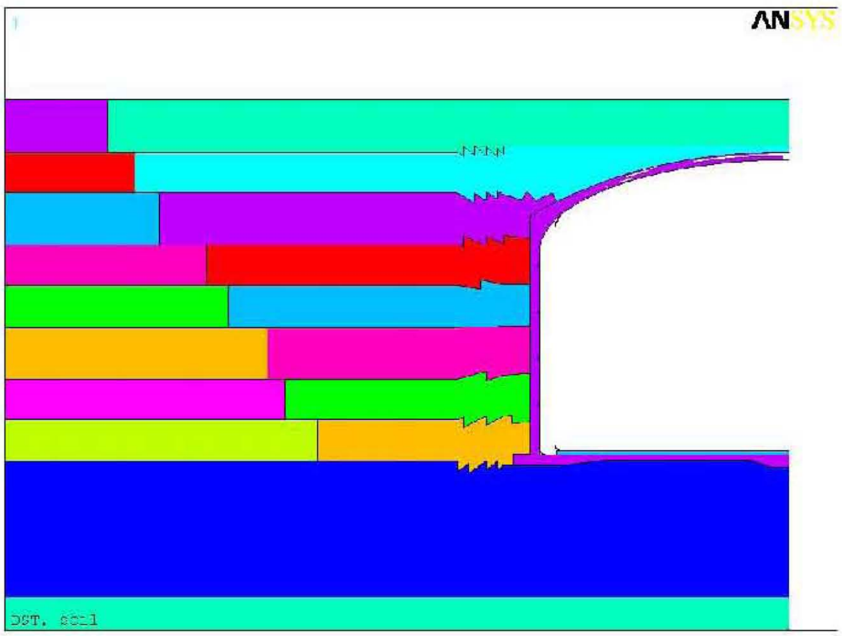


Figure 2-12. Distribution of Soil Properties in the DST Finite Element Model

The soil dimensions are:

Soil depth below foundation:	168 ft
Overburden depth:	8.3 ft
Radial extent (from center of tank):	240 ft
Excavation slope:	Stair-stepped approximation with 1.5:1 slope

The soil constitutive model used for the DST analysis was the ANSYS® Drucker-Prager elastoplastic model. The elastic response is determined by the elastic modulus (E) and the Poisson's ratio (υ). The elastic modulus and Poisson's ratio must be assigned according to the soil depth because the Drucker-Prager model does not adjust the stiffness for confining pressure. The undisturbed soil elastic modulus and Poisson's ratio are shown in Figure 2-13. The compacted backfill soil modulus is shown in Figure 2-14. The backfill Poisson's ratio was constant at 0.27.

The Drucker-Prager plasticity parameters were defined to be constant with soil depth and temperature. The values used are: cohesion = 1.0 psi, friction angle = 35°, and dilatancy angle = 8°. The undisturbed soil density was 110 lb/ft^3 and the compacted backfill density was 125 lb/ft^3. A detailed discussion is presented in the TOLA report (Rinker et al. 2004).

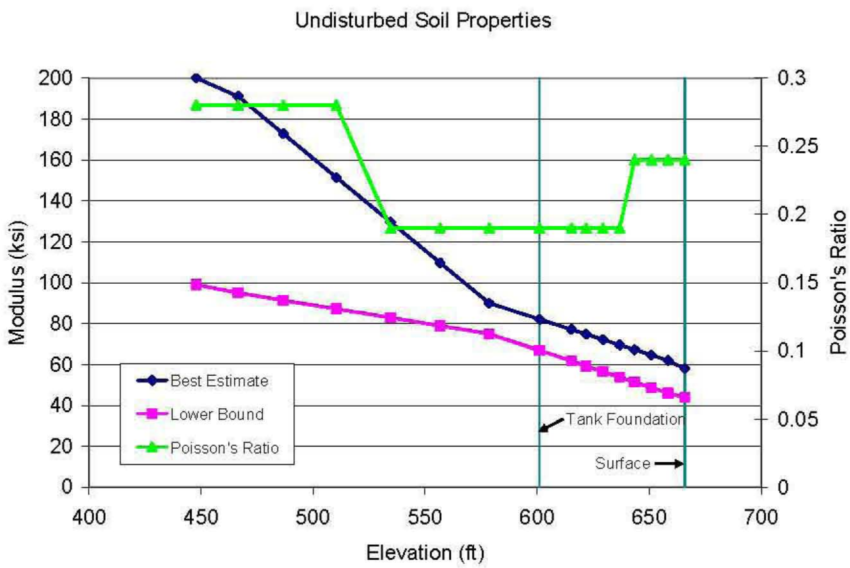


Figure 2-13. Undisturbed Soil Elastic Modulus and Poisson's Ratio

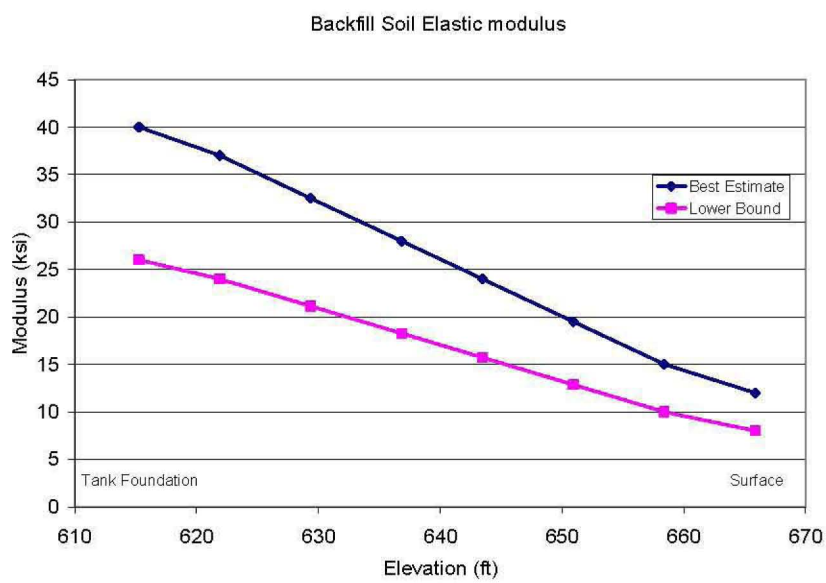


Figure 2-14. Backfill Soil Elastic Modulus

2.3.6 Coefficients of Friction at Material Interfaces

The DST finite element model includes several contact interfaces where friction forces must be accounted for. Table 2-8 summarizes the coefficients of friction (COF) that are used in the DST model. The basis for these values is given in Rinker et al. 2004. The concrete-to-steel coefficient of friction in the dome was reduced to 0.01 for the Rev. 1 reanalysis of anchor bolts. This precluded any relief of the anchor bolt shear forces by friction.

Table 2-8. Coefficients of Friction

Material Interface Description		Coefficient of Friction
Soil-to-Concrete:	Dome	0.3
	Side Walls	0.05
	Base Mat	0.6
Concrete-to-Steel (concrete cast against steel)		0.4
Concrete-to-Steel (insulating concrete-to-primary tank)		0.3
Steel-to-Steel (graphite-lubricated)		0.2

2.4 Loads

This section describes the loads used in the thermal and operating load analysis. A comprehensive description of the load and boundary conditions is found in the TOLA report (Rinker et al. 2004). The TOLA report should be referenced for complete load description and background information.

The load parameters are defined in **SET_PARMS.MAC** and are applied in **APPLY_LOADS_SLICE.MAC**. The loading sequence is defined in **SET_SLICE.MAC** and subsequent input files.

2.4.1 Thermal Loads

The temperature distributions described in the TOLA report (Rinker et al. 2004) were applied as thermal loads. The temperature profiles represented a yearly thermal cycle that includes the design basis heat up transient, a steady-state dwell time at the maximum design waste temperature, followed by the design basis temperature cool down transient. Table 2-9 summarizes the time and waste temperatures that comprise the cycle. Multiple temperature distributions were solved during the waste heating and cooling segments of the transient to ensure that the maximum effect of the transient temperature gradients was captured in the structural evaluations of the concrete and steel sections. It was also conservatively assumed that the steady-state temperature distribution corresponding to a maximum waste temperature of 350°F was achieved at the end of the high-temperature segment of the transient. This ensures that the maximum concrete temperatures and the maximum thermal degradation in the concrete strength and stiffness is considered. At the low waste temperature of 50°F it was also assumed that the transient ended with the tank and surrounding soil returning to the uniform 50°F initial temperature. The mechanical analyses assume 50°F as the initial stress-free temperature for the soil, steel, and concrete.

The DST model temperatures are used in the analysis for including the effects of concrete thermal degradation, temperature-dependent steel properties, and differential thermal expansion between the steel and the concrete. The different temperature fields corresponding to the mechanical solution (steps 2 through 16 in Table 2-9) are shown in Figures 2-15 through 2-27. (Note that solution steps 8, 9, and 10 are the same temperature state and only plotted once.) Data files for the temperature distributions are prohibitively large for inclusion in this report as appendices but are available on the electronic media version of this report.

The service life of the DSTs ranges from 20 to 50 years. For the purpose of this analysis, a life of 60 years was selected. This value was chosen based on the number of years already in service and the anticipated continuing waste storage. While the historical data suggest a three-year full-temperature cycle, an annual cycle was conservatively specified for the thermal loading. However, the completion of an analysis with 60 thermal cycles proved problematic with the model convergence issues. Review of the preliminary results demonstrated little change in the concrete cracking, concrete force and moments and tank stress beyond the first several cycles. In addition, the creep rate decreases over time (see Chapter 3). Accordingly, analyses consisted of one thermal cycle per year for five years followed by 55 years of creep at elevated temperature and concluding with a final thermal cycle as described in Section 2.4.4.

Table 2-9. Temperature States that Define the Design Basis Annual Thermal Cycle for the ANSYS® Structural Model

Step No.	Comment	Days	Waste Temp., °F	Plot Label
1	Initial Temperature = 50°F uniform	0	50	
2	Fast heat to 125°F (@ 10°F/hour)	0.3	125	h1
3	First step to 350°F (@ 20°F/day)	3.3	181.3	h2
4	Second step to 350°F	6.3	237.5	h3
5	Third step to 350°F	9.3	293.8	h4
6	Fourth step to 350°F	12.3	350	h5
7	Intermediate step toward Steady-state	30	350	h6
8	Steady-State @ 350°F	45	350	ss
9	Hold – Steady-State @ 350°F	350	350	hold
10	Material Property Change	351	350	
11	First step to 125°F cool down (@ 20°F/day)	354	293.8	c1
12	Second step to 125°F	357	237.5	c2
13	Third step to 125°F	360	181.3	c3
14	Fourth step to 125°F	362.3	125	c4
15	Fast cool down to 50°F (@ 10°F/day)	362.6	50	c5
16	Tank cool down transient to 50°F	363.6	50	c6
17	Uniform 50°F	365	50	

The temperature distributions were revised for the Rev. 1 anchor bolt reanalyses. Tank Farm Operations has indicated that a waste temperature 160°F is an adequate bound for all current and future operation. Furthermore, the higher temperatures are recorded in the waste lower in the tank. The liquid temperature near the surface of the waste are bounded at 135°F. The TOLA model was run for 20 years of equivalent thermal cycling at 350°F waste temperature followed by 40 years of equivalent thermal cycling with the primary tank at 160°F and the dome temperatures based on 135°F waste surface temperature. Fewer load steps were required to resolve the thermal transient because of the smaller temperature variation. Additionally, the baseline (stress-free) temperature was taken as 80°F as described in Appendix B of the Increased Liquid Level Rev. 1 report (Deibler et al. 2008).

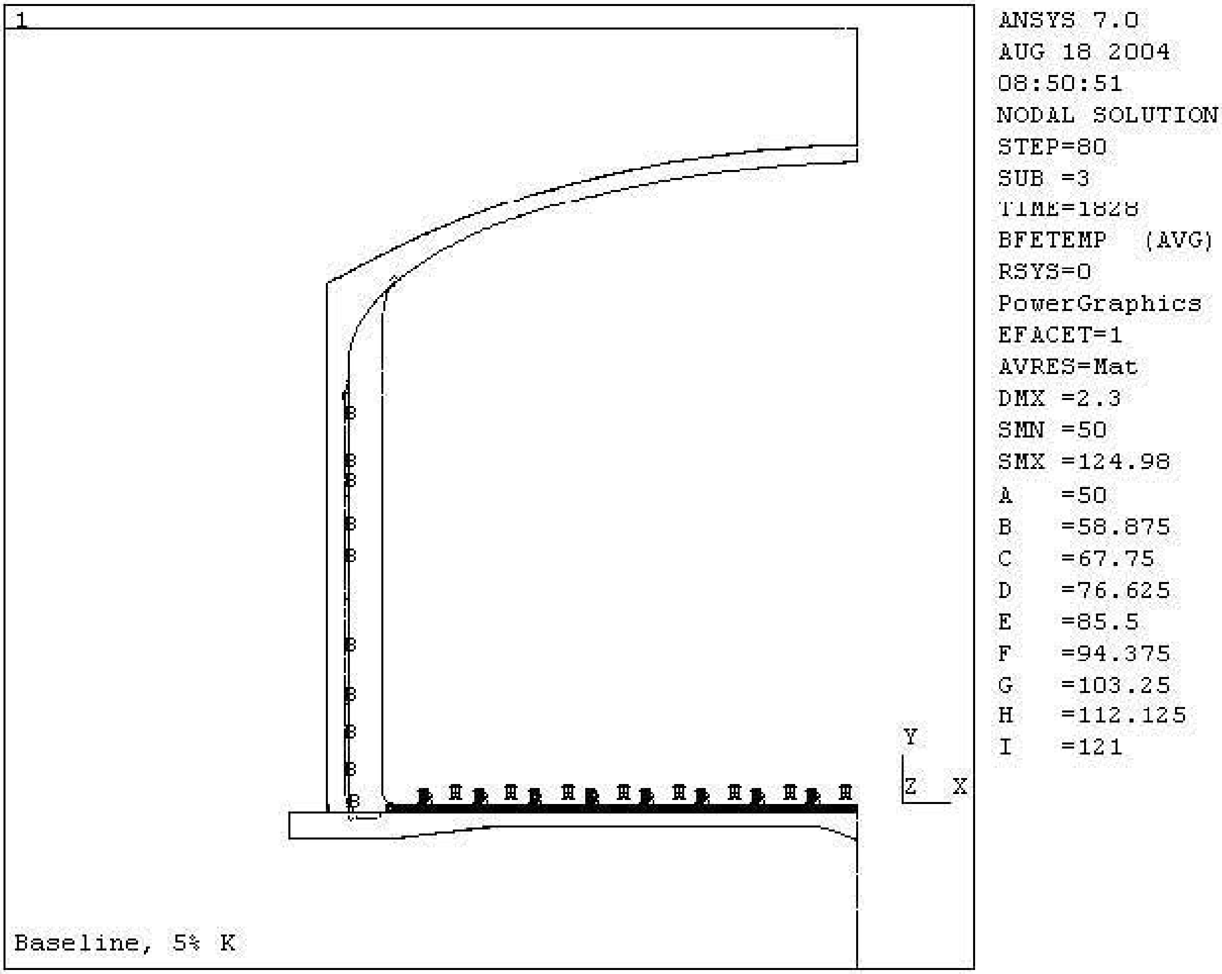


Figure 2-15. Temperature (°F) Distribution at Step 2 (Table 2.9) in the Design Basis Transient (Waste temperature = 125°F.)

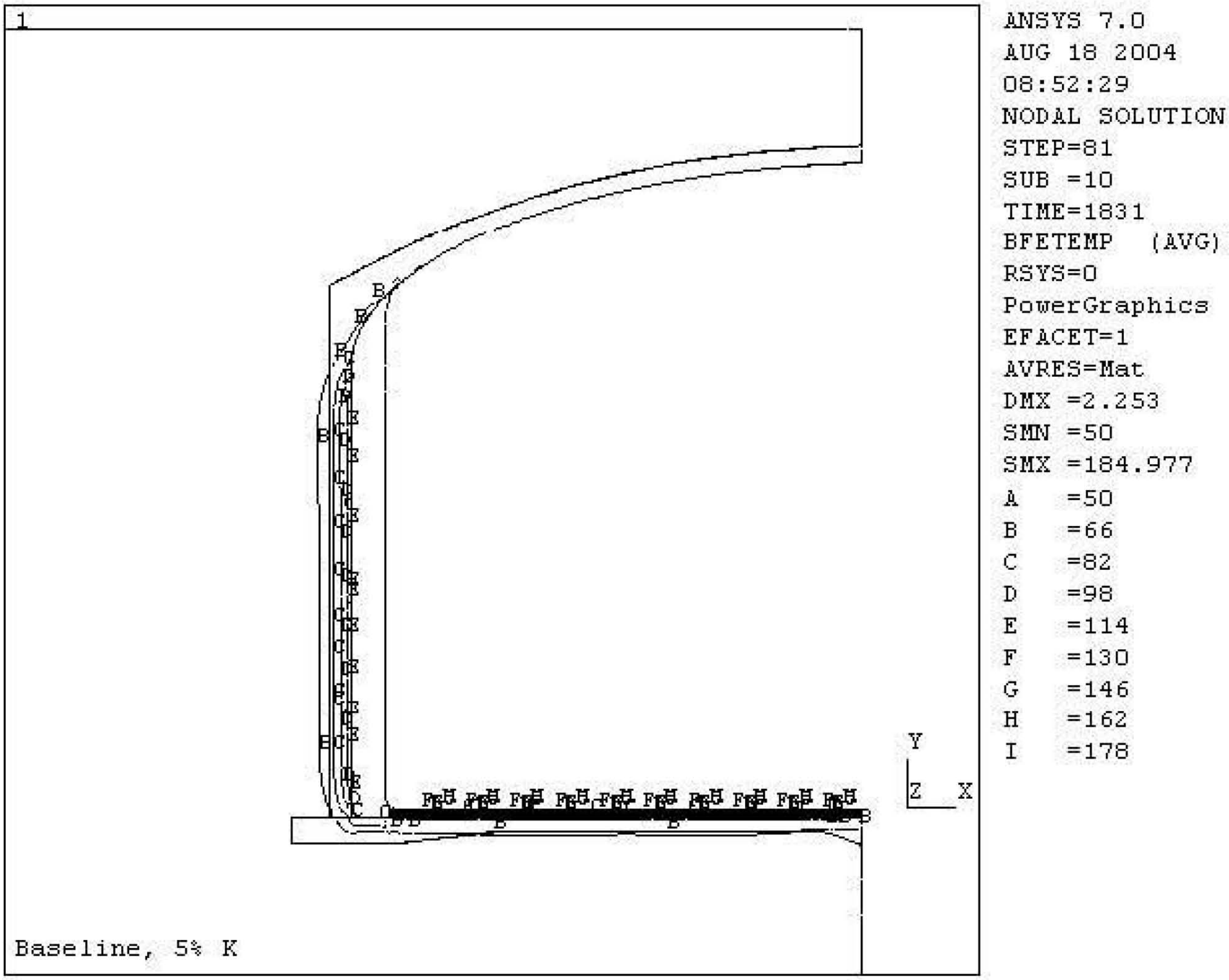


Figure 2-16. Temperature (°F) Distribution at Step 3 (Table 2-9) in the Design Basis Transient (waste temperature = 181.3°F)

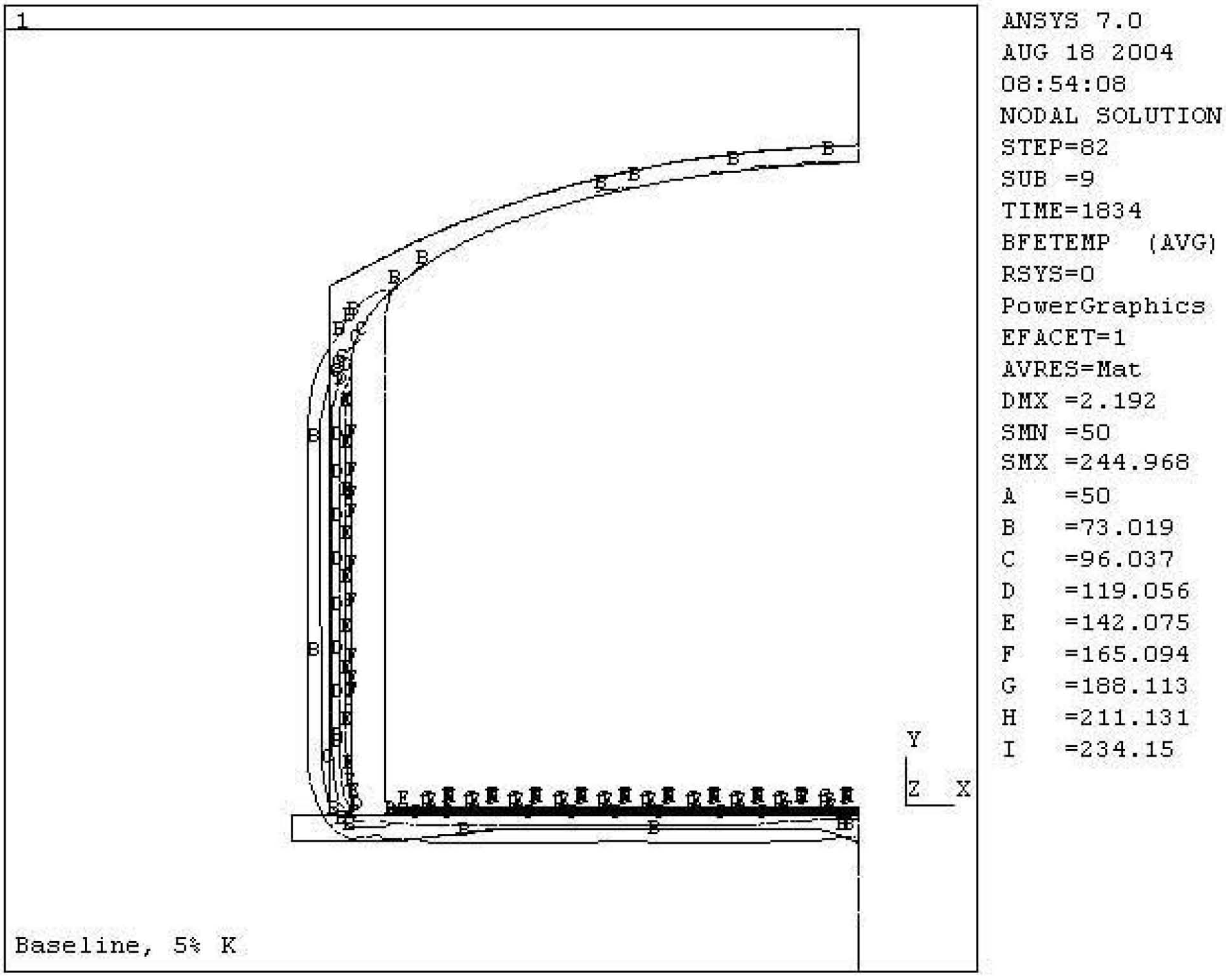


Figure 2-17. Temperature (°F) Distribution at Step 4 (Table 2-9) in the Design Basis Transient (waste temperature = 237.5°F)

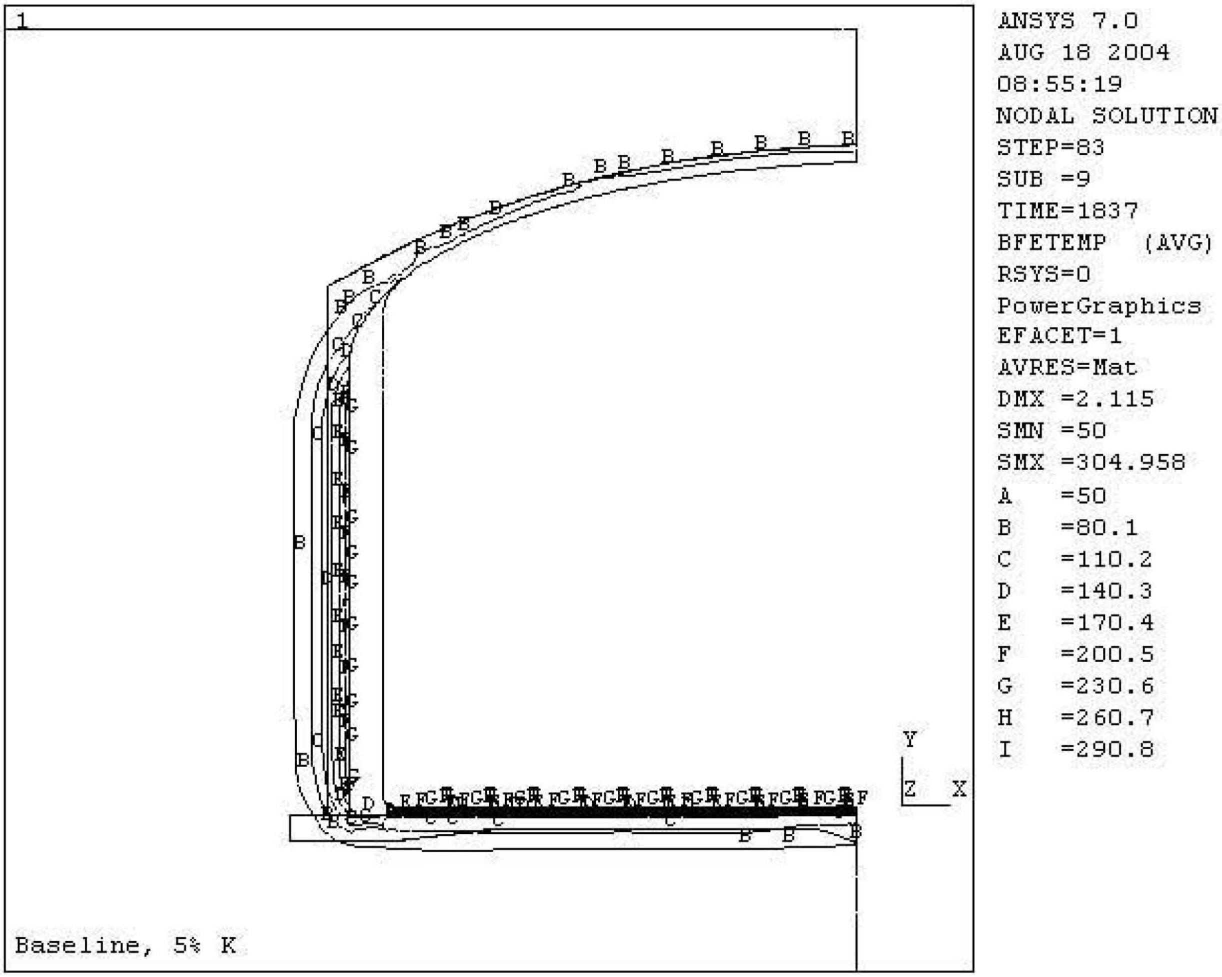


Figure 2-18. Temperature (°F) Distribution at Step 5 (Table 2-9) in the Design Basis Transient (waste temperature = 293.8°F)

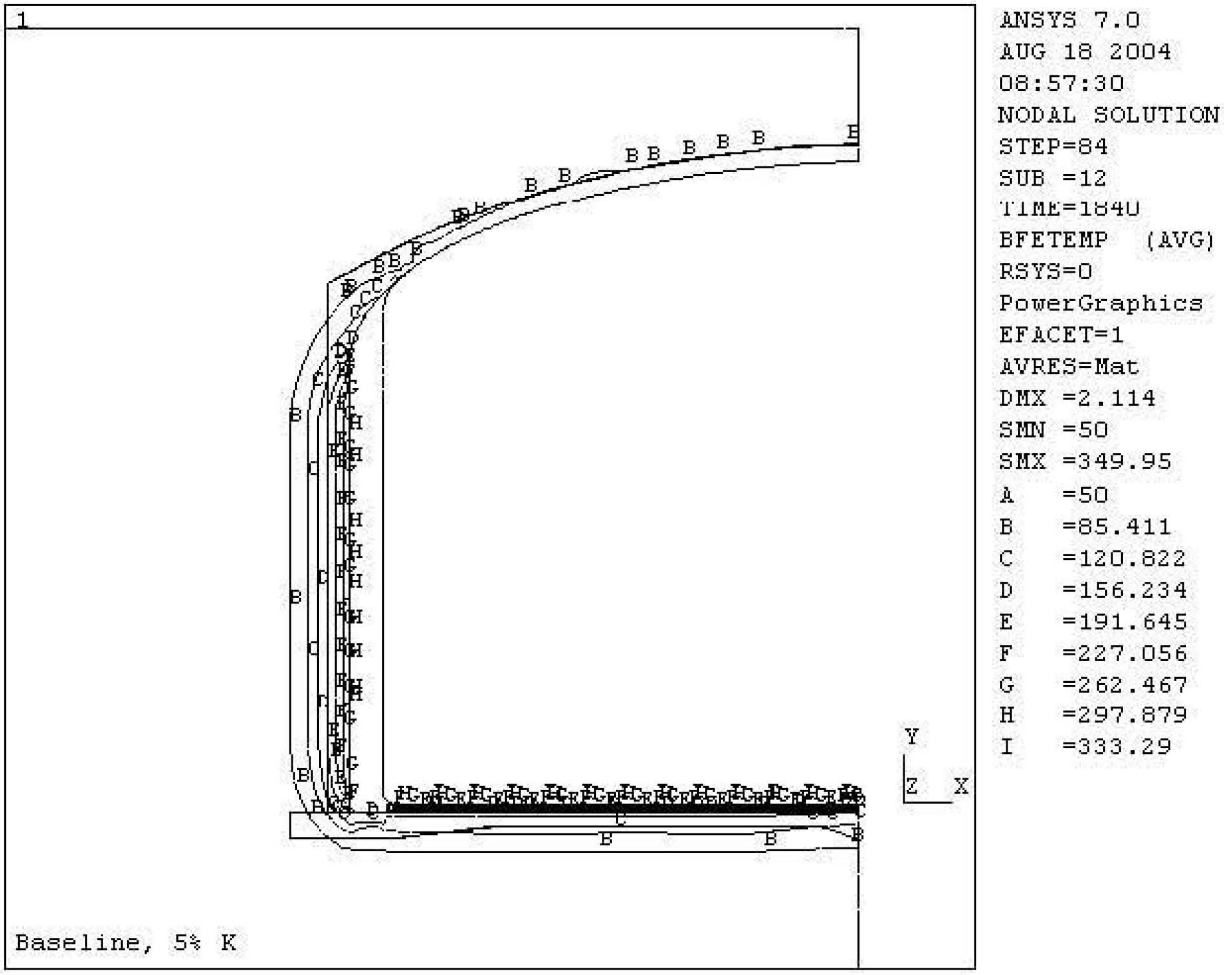


Figure 2-19. Temperature (°F) Distribution at Step 6 (Table 2-9) in the Design Basis Transient (waste temperature = 350°F)

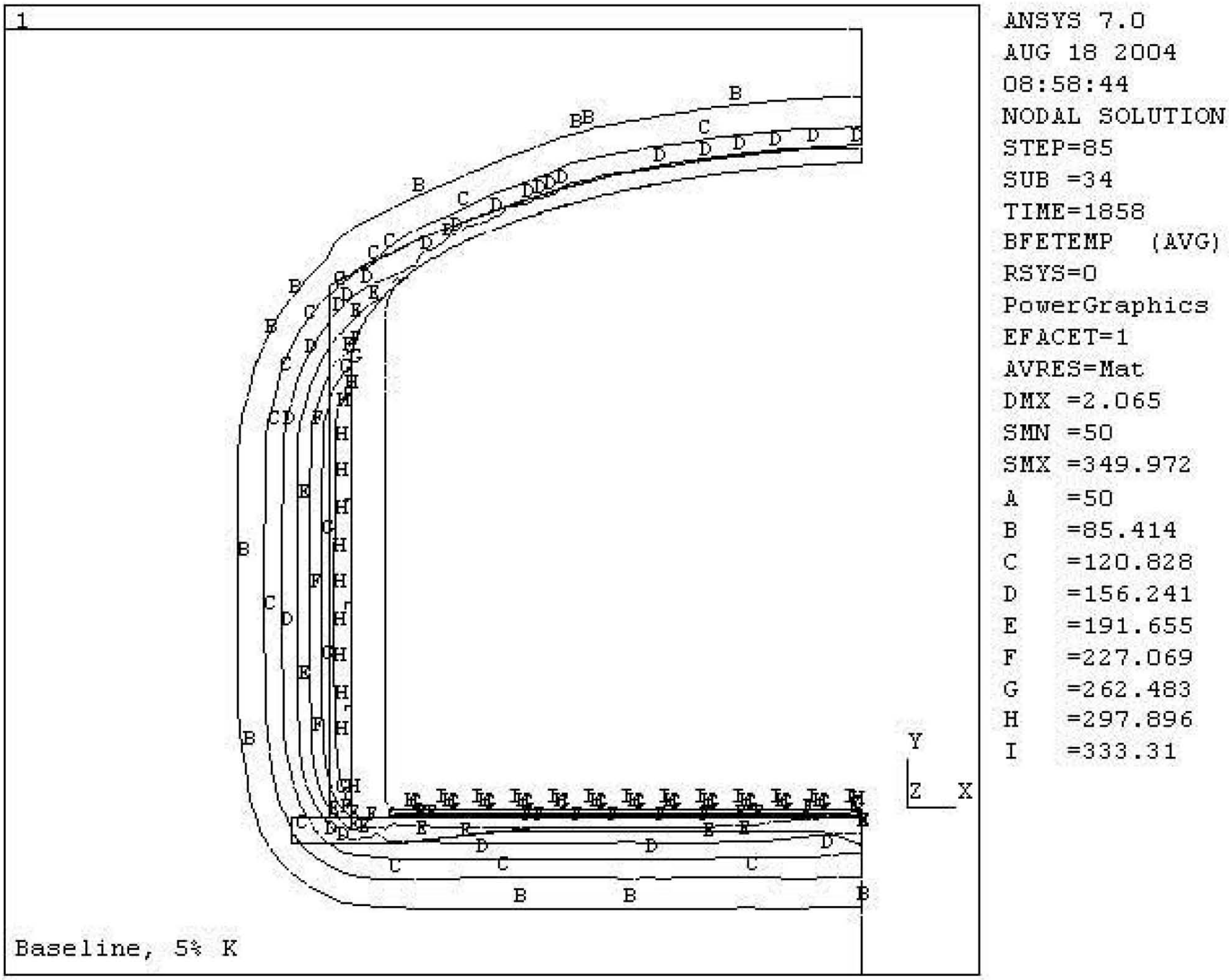


Figure 2-20. Temperature (°F) Distribution at Step 7 (Table 2-9) in the Design Basis Transient (waste temperature = 350°F)

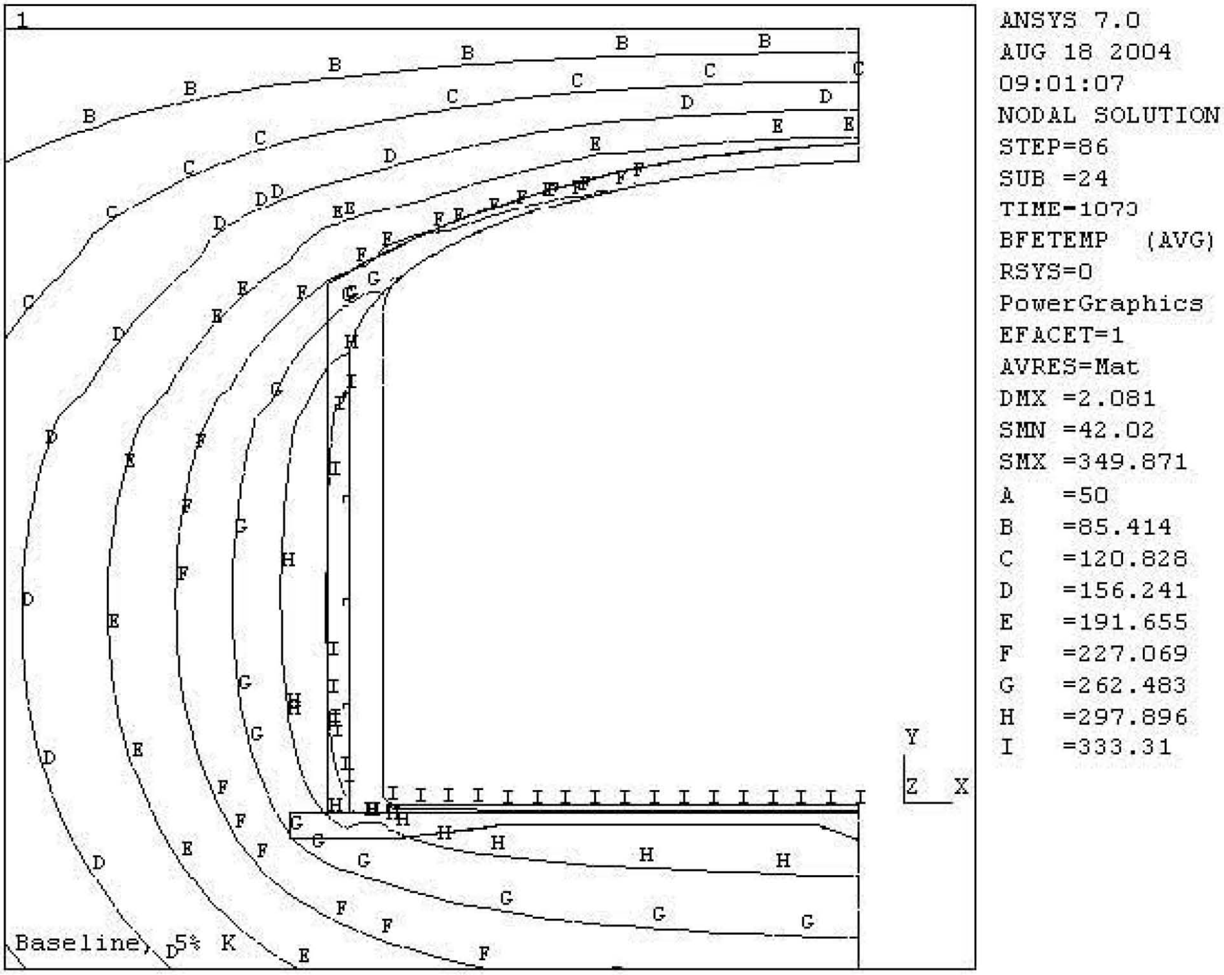


Figure 2-21. Steady-State Temperature (°F) Distribution at Steps 8, 9, and 10 (Table 2-9) in the Design Basis Transient (waste temperature = 350°F)

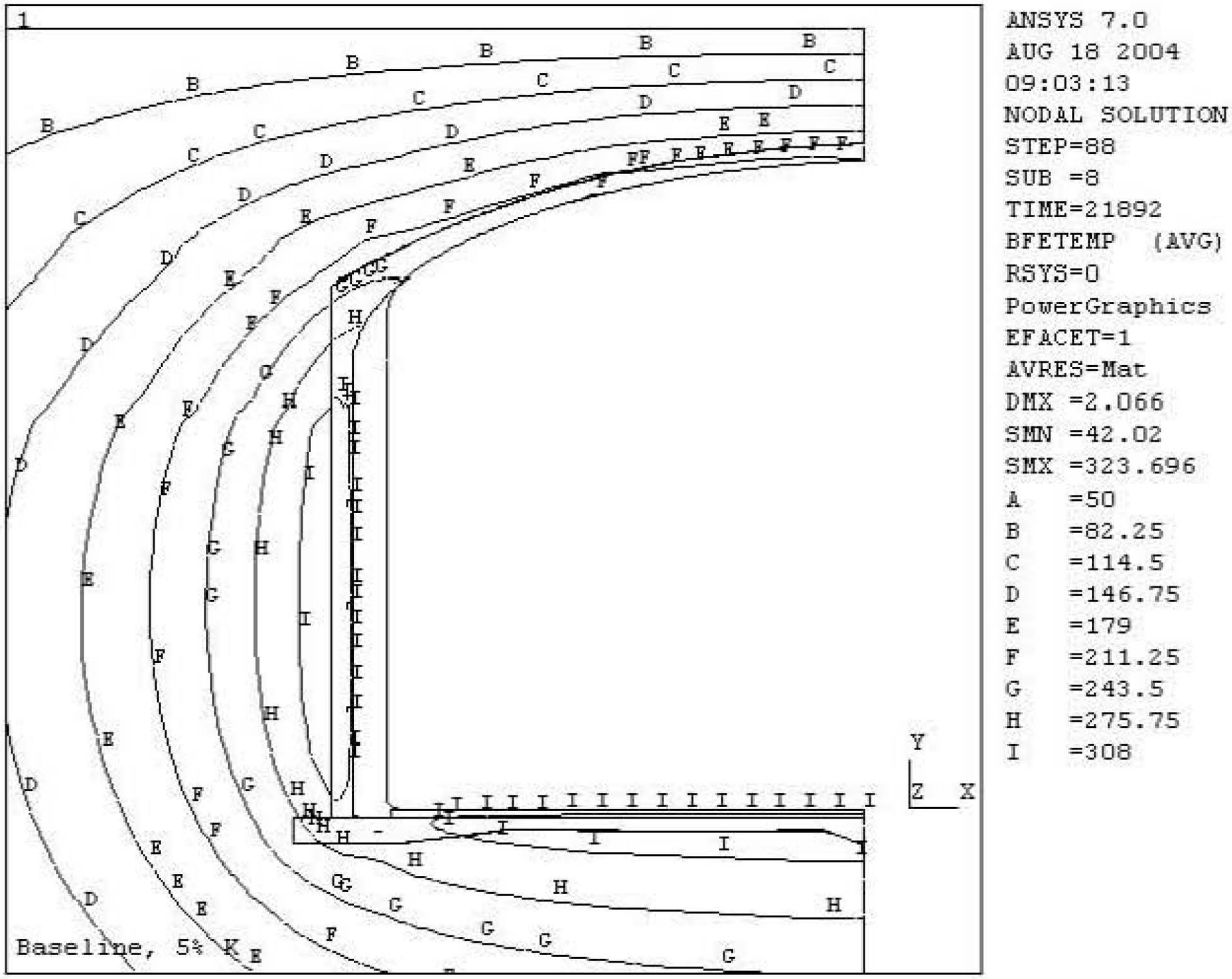


Figure 2-22. Temperature (°F) Distribution at Step 11 (Table 2-9) in the Design Basis Transient (waste temperature = 293.8°F)

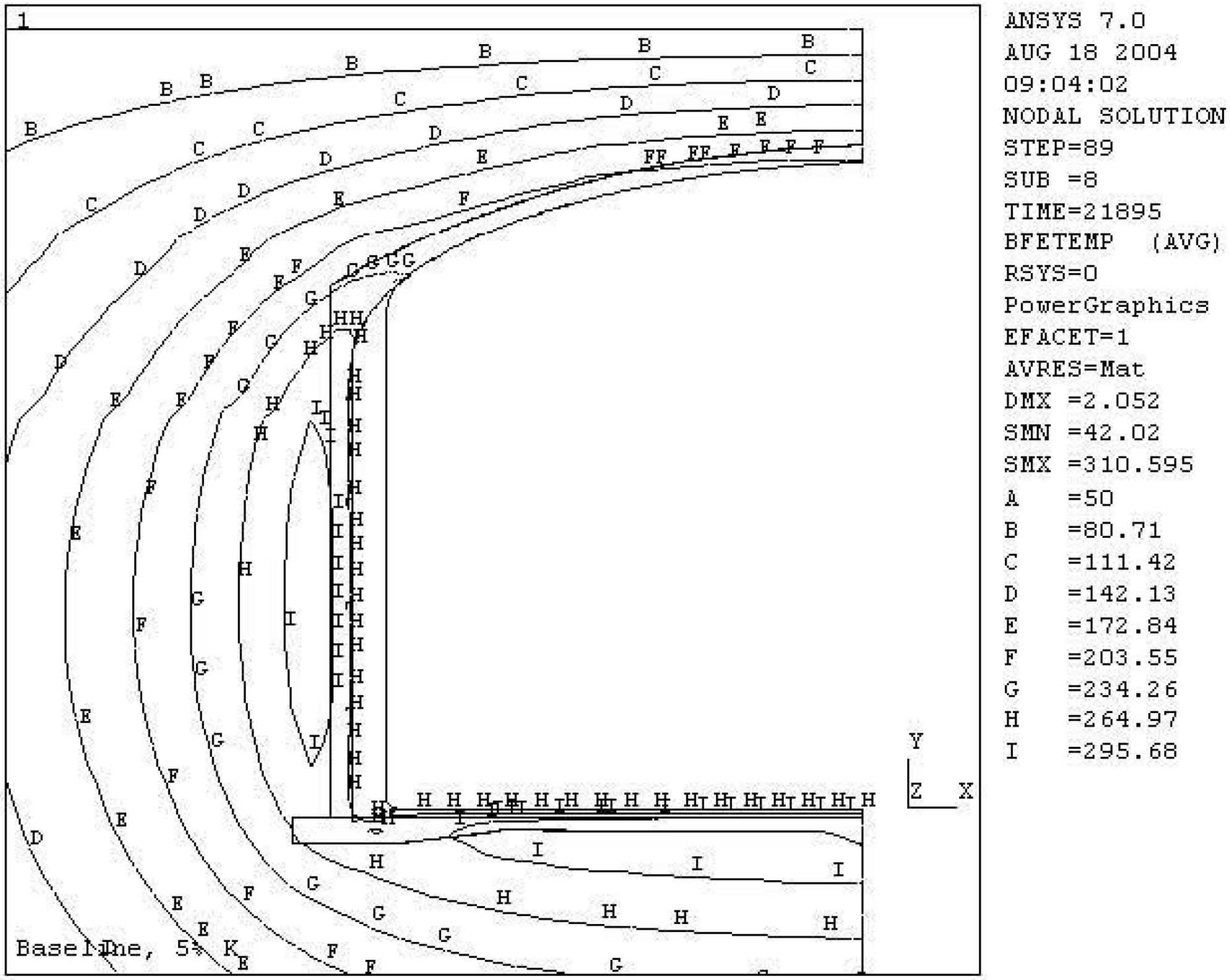


Figure 2-23. Temperature (°F) Distribution at Step 12 (Table 2-9) in the Design Basis Transient (waste temperature = 237.5°F)

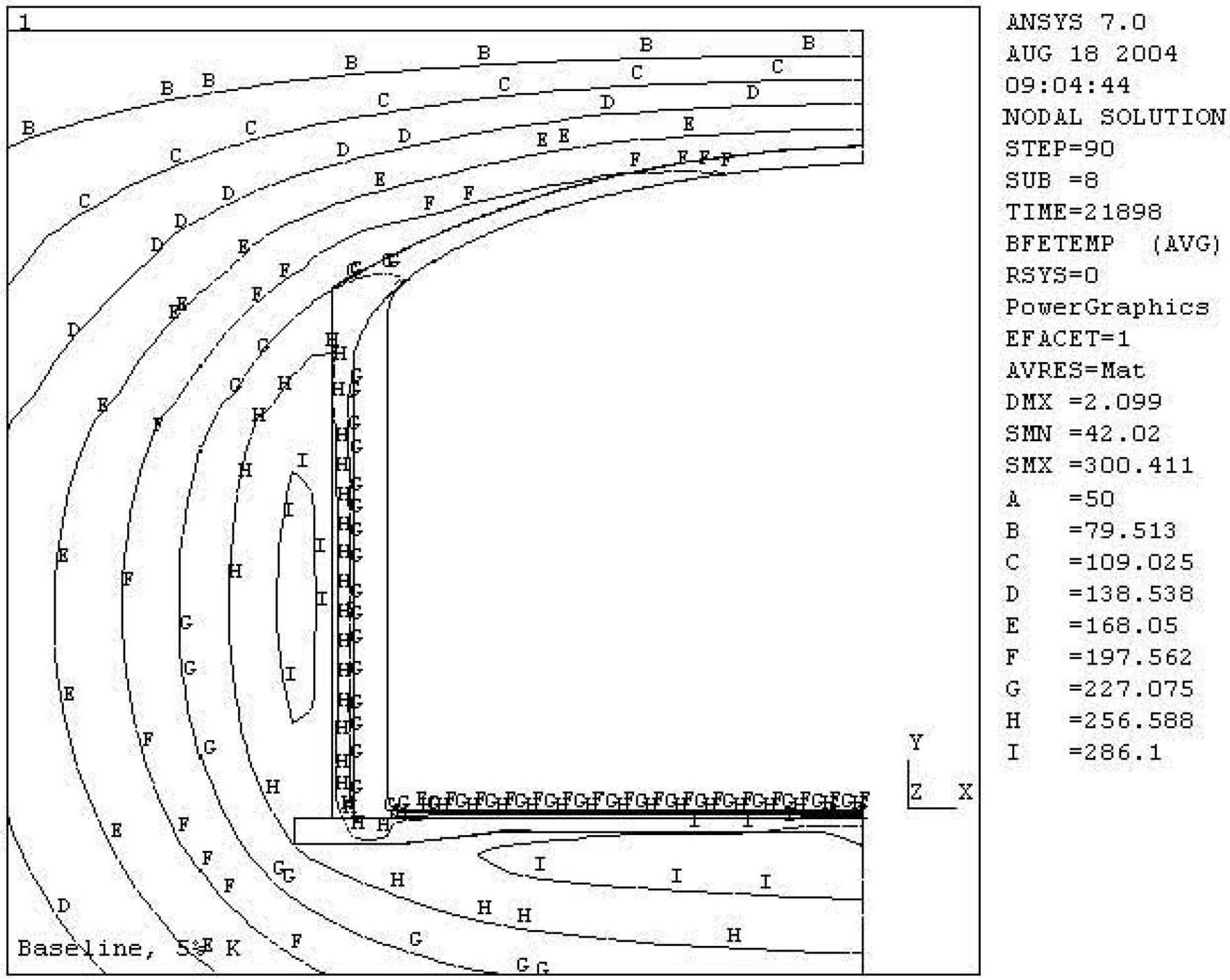


Figure 2-24. Temperature (°F) Distribution at Step 13 (Table 2-9) in the Design Basis Transient (waste temperature = 181.3°F)

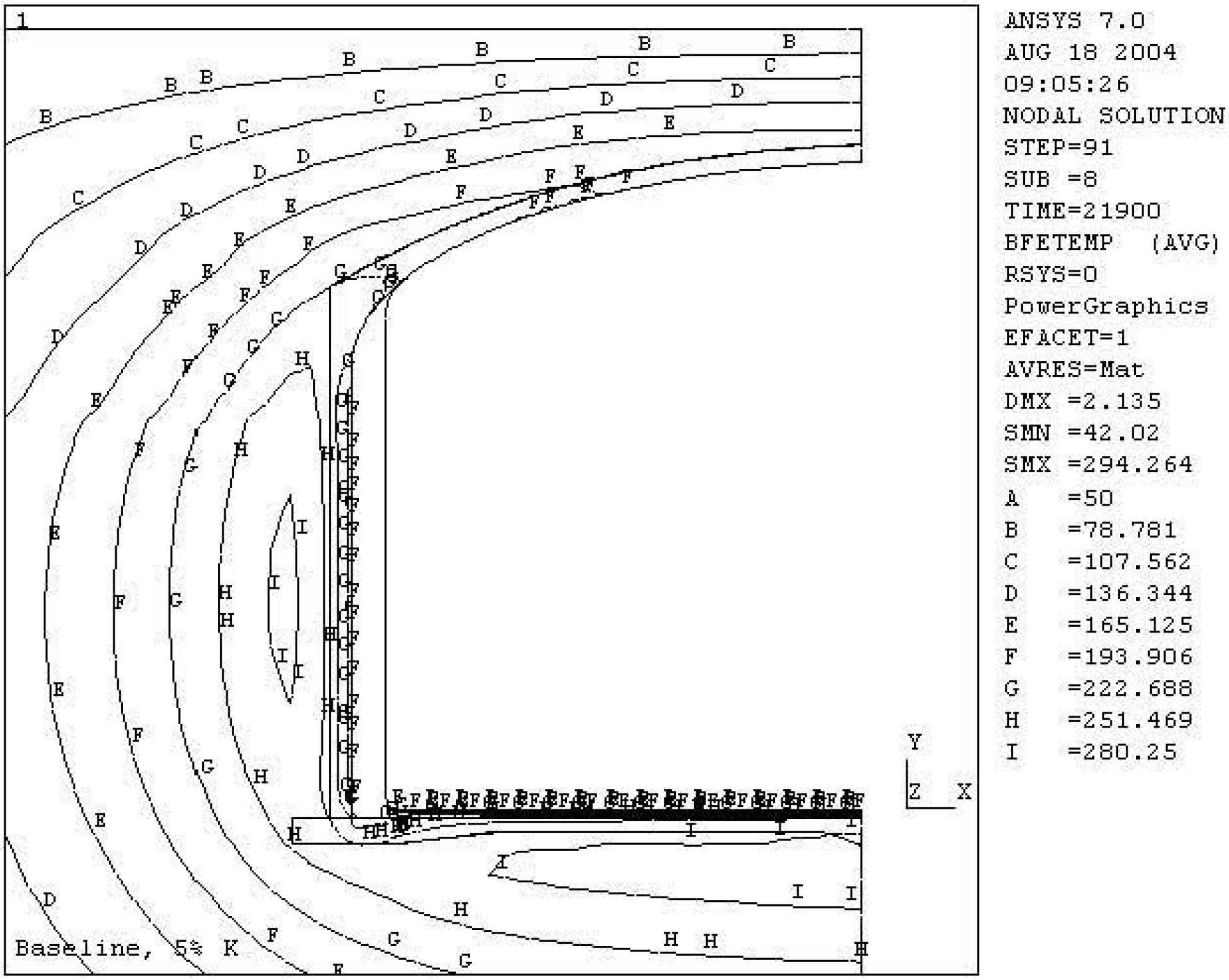


Figure 2-25. Temperature (°F) Distribution at Step 14 (Table 2-9) in the Design Basis Transient (waste temperature = 125°F)

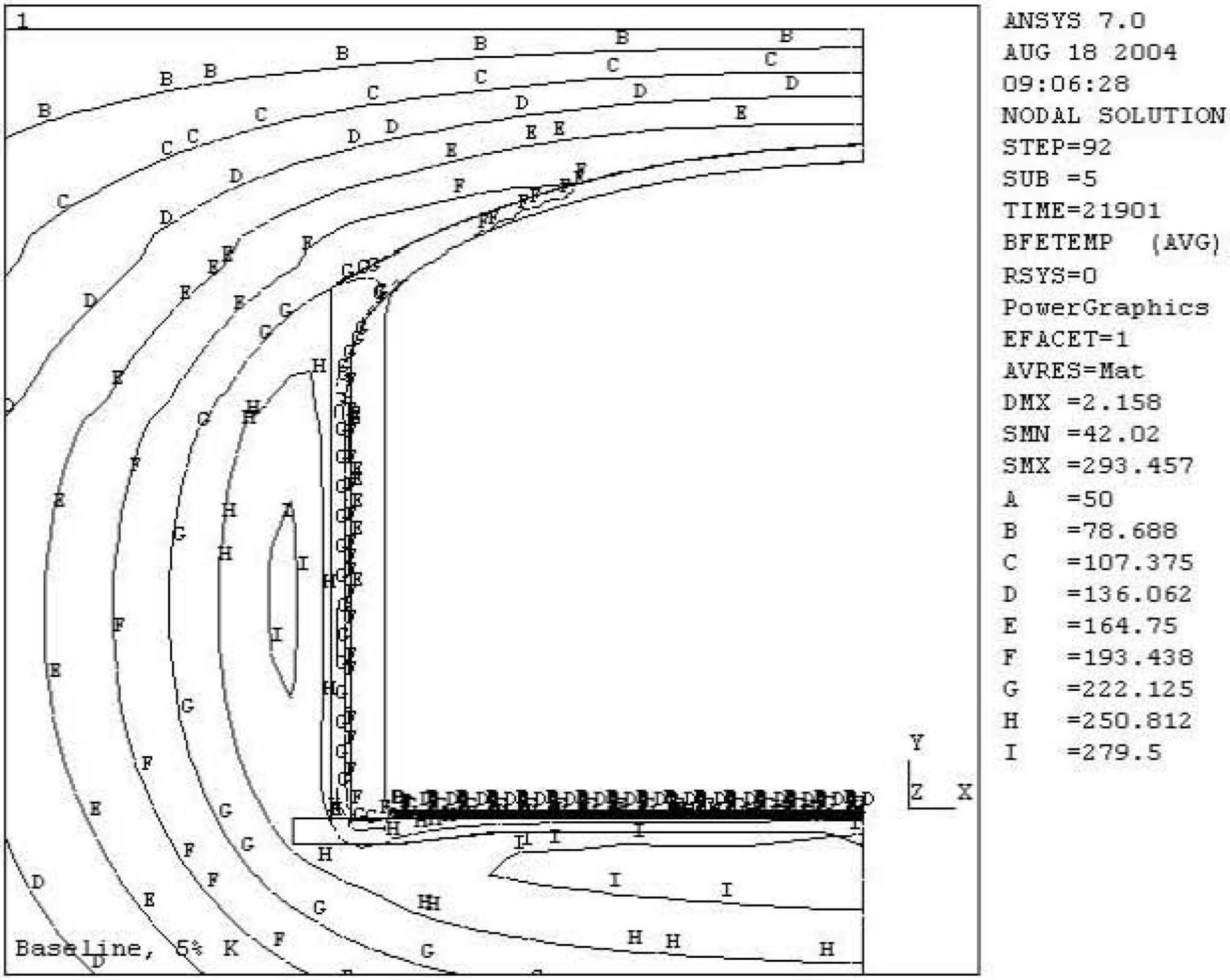


Figure 2-26. Temperature (°F) Distribution at Step 15 (Table 2-9) in the Design Basis Transient (waste temperature = 50°F)

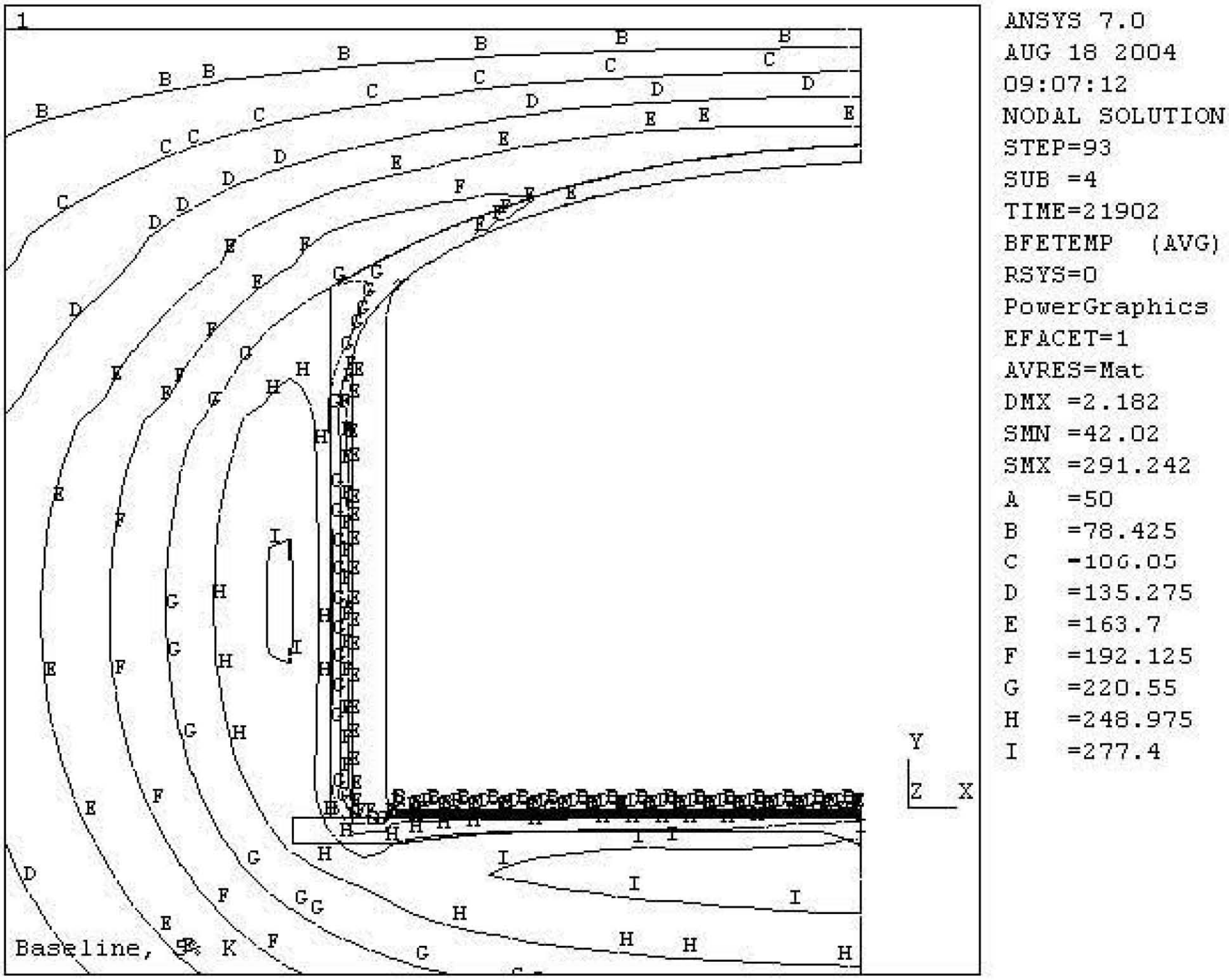


Figure 2-27. Temperature (°F) Distribution at Step 16 (Table 2-9) in the Design Basis Transient (waste temperature = 50 °F)

2.4.2 Mechanical Loads

Table 2-10 lists the non-seismic loading conditions that are specified in the statement of work for this project. The list contains both structural and thermal operating loads that are both static and transient in nature. The concentrated live load was increased at the end of the nominal 60-year analysis.

Table 2-10. DST Load Conditions for Analysis

Design Load	Value	Notes
Design Life	> 50 years	A 60-year design life is used.
Maximum Corrosion Rate	1 mil/yr	A total corrosion allowance of 0.060 inch is applied to the specified nominal thicknesses.
Soil Cover	8.3 ft @ 125 lb/ft^3	Relative to dome apex.
Hydrostatic	422 inches @ 1.7 SpG	
Pressure	-6 or -12 in. wg (water gauge) $\leq P_{primary} \leq$ +60 in. wg	Primary Tank; -12 in. w.g. applies to AP only
	-20 in. wg $\leq P_{annulus} \leq$ +60 in. wg	Annulus; -20 applies to AP; -6 for all others
	-6 or -12 in. wg $\leq P_{primary} - P_{annulus}$	Differential; -12 in. w.g. applies to AP only
Live Load	40 lb/ft^2	Uniform
	200,000 lb. nominal	Concentrated
Thermal	350°F	Maximum bulk temperature of waste
	20°F/day	Waste maximum heatup/cooldown rate
	1/yr	Cyclic rate

2.4.3 ACI Load Factors

The load factors required by ACI 349 were achieved be directly applying them to the relevant load in a separate load step. The load factors to be applied in this analysis are a subset of the possible combinations specified in ACI 349-90, Section 9.2 (ACI 1992). The subset is defined by WHC-SD-WM-DGS-003 (Day et al. 1995) and further reduced by the TOLA work scope (Rinker et al. 2004). The normal operating and thermal loads specified for analysis are:

U = Demand Load (comprised of combinations of the following):
D = Dead Load (tank + overburden + concentrated dead load + piping and equipment)
L = Live Loads
L1 = uniform live load
L2 = concentrated live load
F = Hydrostatic waste pressure
V = Vapor pressure loading (annulus and vapor space)
H = Lateral soil pressure
T = Thermal load (internal forces and moments caused by temperature distribution within the concrete). Normal (T_o) and abnormal ($T_{abnormal}$) cases are specified. As described in Chapter 4, the abnormal temperature cases are bounded by the design thermal transient that is applied in the thermal and operating loads analysis.
R_o = Piping and equipment reactions[(a)]

(a) R_o is not considered in this analysis.

WHC-SD-WM-DGS-003 does not distinguish L1 from L2, or V from F. Those items are combined into L and F. We chose to maintain a distinction and combine them algebraically as a matter of form.

The applicable ACI load combinations reduce to:

Load Combination 1: $U = 1.4(D + F + V) + 1.7(H + L1 + L2)$
Load Combination 4: $U = D + F + V + H + L1 + L2 + T$
Load Combination 9: $U = 1.05D + 1.05(F + V) + 1.3(L1 + L2 + H) + 1.05T_o$

Load Combination 9 is, in terms of load factors, intermediate between Load Combination 1 and Load Combination 4. Instead of applying Load Combination 9, we conservatively applied Load Combination 1 then added the thermal loads with the temperatures increased by 5% as discrete load steps; that is, Load Combination 9': $U = 1.4 (D+F+V) + 1.7 (H+L1+L2) + 1.05 T$. The focus of the results presented in Chapter 6 is on load combination 9' as it is the most severe load combination with limited results presented for load combination 1. It is noted that when the seismic demand is included with the appropriate load combinations, it may have only a small affect on the maximum concentrating load.

2.4.4 Load Step Procedure

Figure 2.28 shows the flow plan used to model the 61 years of thermal cycles and creep and subsequent increased concentrated load analysis. The analysis is divided into several distinct analyses to facilitate a restart in the event of convergence difficulties. The initial 5 years of thermal cycles was interrupted after year 2 to provide the first restart point. The year 5 to 60 phase is a single thermal cycle held at the steady state temperature condition for nominally 55 years. A final thermal cycle (year 61) is performed to capture any effect the long term creep may have had on the cracking of the concrete and subsequent load distribution. The increase in concentrated load is then applied. The ACI load combination 1 evaluation is carried out and then an additional thermal cycle is completed with the temperatures increased by 5%. This provides a conservative evaluation of load combination 9.

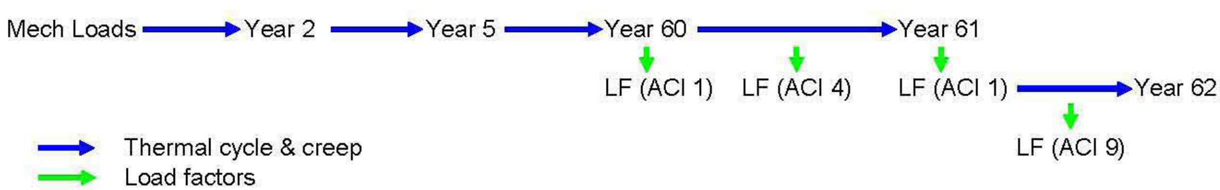


Figure 2-28. Analysis Flow Plan

3.0 Seismic Model

3.1 Introduction

This chapter describes the ANSYS® finite element (FE) model, material properties, loads used for the double-shell tank (DST) seismic analysis. Complete documentation of the model is found in the Seismic Analysis report (Abatt and Rinker 2008). The current report contains summaries of the model, material properties and loads. The Seismic Analysis report should be referenced for complete model description and background information.

3.2 Finite Element Model

This section describes the geometry and construction of the ANSYS® finite element model of the DST and the waste. A comprehensive description of the FE model is found in the Seismic Analysis report (Abatt and Rinker 2008). The Seismic Analysis report should be referenced for complete model description and background information.

3.2.1 Model Description

A seismic model of a Hanford DST was created and analyzed using version 8.1 of the general purpose finite element program ANSYS®. A half-symmetry model of the DST, including the concrete tank, primary tank, secondary liner, anchor bolts, waste, and surrounding soil was developed to evaluate the seismic loading on the DST. Figure 3-2 shows the complete model. Details for each part of the model are discussed in the following sections.

The bounding tank model geometry was based on the AY tank configuration shown in Hanford Drawing No. H-2-64449. The primary tank has a 450 in. radius and the height of the vertical wall is 424 in. The dome apex is 561.5 in. above the bottom of the tank. The models were run using waste depths of 422 in. An excerpt from Drawing No. H-2-64449 is shown as Figure 3-1. The complete model, including the DST and surrounding soil, is shown in Figure 3-2.

A significant effort was undertaken to determine the best approach for modeling various aspects of the tank and surrounding soil. Rinker et al. (2006a), provides a discussion of the development of the soil model, including material properties and boundary conditions. Rinker et al. (2006b) and Abatt and Rinker (2008a) document benchmarking studies for the methodology used to model the waste. The reports provide comparisons to theoretical fluid/structure interaction predictions of waste pressures and total hydrodynamic reactions to those obtained from ANSYS® and Dytran models.

The detailed ANSYS® model was developed based on coordinates developed for models used in the static tank analyses. A series of input files were used to break the model creation into manageable parts. The files used, and a short description is provided in Table 3-1. All input files are provided in the Seismic Analysis report (Abatt and Rinker 2008).

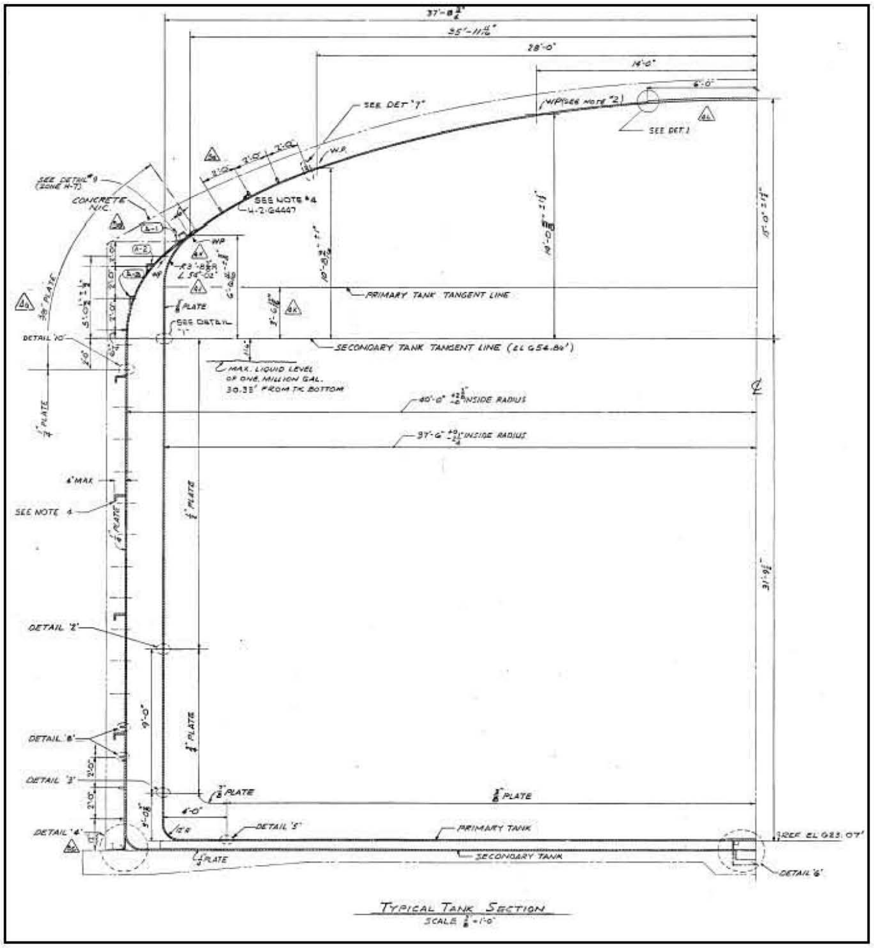


Figure 3-1. AY Primary Tank Dimensions

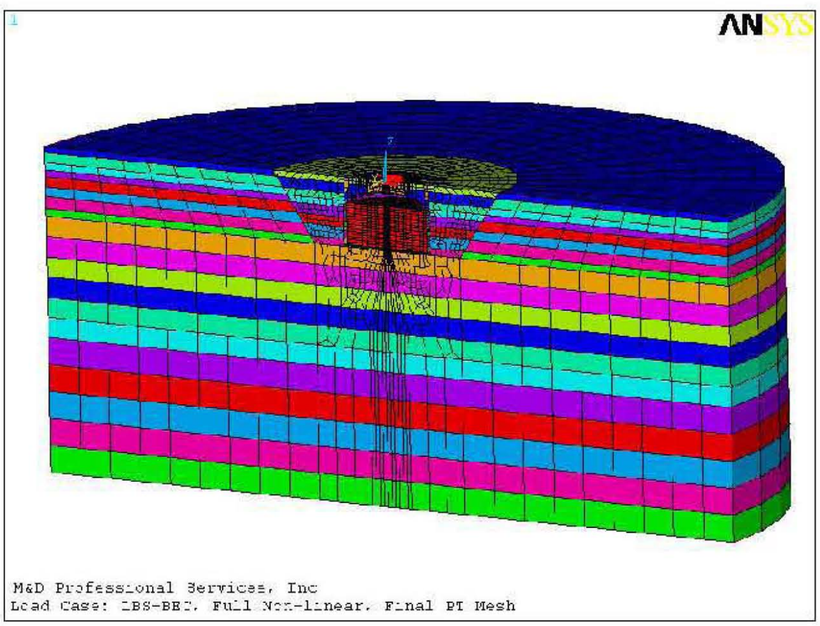


Figure 3-2. Composite Tank Model Detail

Table 3-1. ANSYS Model Input File Description

File Name	Description
Run-Tank.txt	Calls each input for development of model
Tank-Coordinates-AY.txt	Defines key geometry and model parameters. Concrete geometry set to match PNNL section cut locations.
Tank-Props-###.txt	Defines concrete material and real properties for model. Uses properties based on Best Estimate or Fully Cracked conditions. Each tank layer can be assigned unique properties
Tank-Mesh1.txt	Creates concrete tank mesh. Foundation and wall are separate entities
Primary-Props-AY.txt	Defines primary tank material and real properties.
Primary.txt	Creates primary tank mesh. Primary tank is not connected to concrete tank.
Insulate.txt	Creates insulating concrete mesh. Uses existing geometry from concrete and primary tanks, but is not connected.
Waste-Solid-AY.txt	Creates model of waste. Uses Solid45 elements with low shear modulus. Uses primary tank geometry.
Interface1.txt	Creates interface connections or contacts between pieces of model
Interface-gap1.txt	Creates interface connections or contacts between pieces of model
Bolts-friction.txt	Creates elements for anchor bolts and contact surface between the primary tank and concrete tank in the dome
Liner.txt	Creates elements for Secondary Liner
Near-Soil-1.txt	Creates soil model for excavated region around tank. Merges coincident nodes with concrete tank.
Soil-Props-###-Geo.txt	Defines all soil geometry and material properties. Excavated region and native soil have different material properties. Unique files are used for each soil condition (UB, BE, LB).
Far-Soil.txt	Creates far-field/native soil to a radius of 320 ft and depth of 266 ft. Merges coincident nodes with near soil and concrete tank. Places large mass at bottom of model for excitation force.
Fix-Soil.txt	Creates the contact interface between the excavated soil and native soil portions of the model
Slave.txt	Creates slaved boundary conditions around exterior of model.
Boundary.txt	Creates boundary conditions for symmetry. Does not set boundary conditions for solution phase.
Live_Load.txt	Applies surface concentrated load over center of dome
Outer-Spar.txt	Creates spar elements at edge of soil model to control shear behavior.

All components of the model are based on 9-degree slices over the half model, for a total of twenty slices.

The model description will address the tank components first, then the surrounding soil.

3.2.2 Concrete Vault

The first component developed in the model is the concrete tank shell and footing. Thirty-three sections are used between the dome and center of the floor for each 9-degree slice. In the detailed TOLA model, seventy sections were identified and used for extracting forces and moments. Using the profile coordinates for these seventy sections, a subset of 33 sections was developed for the profile of the ANSYS® seismic model (See Table 3-2). Based on the need to allow for connecting other portions of the full model, some coordinates were adjusted relative to the TOLA model.

The geometry of the concrete tank is based on a combination of data from drawings and TOLA model. The basic geometry is based on drawings H-2-64310 and H-2-64307. Nodal locations were selected to correspond reasonably well to the TOLA model. This was done to simplify load combinations. Table 3-2 provides a listing comparison of nodal coordinates for the ANSYS® seismic model and TOLA model.

Input file "Tank-Coordinates-AY.txt" is used to read coordinate data for the concrete tank.

Table 3-2. Concrete Tank Centerline Coordinates

		Coordinates			**ANSYS**		
	Section	**R (inch)**	**H (inch)**	**T (Inch)**	**X**	**Z**	**Set #**
		0	568.6	15	0	568.8	1
Dome	1	30.2	568.6	15			
				15	45	568	2
Dome	2	61.4	567.5	15			
Dome	3	90.4	565.8	15	90.4	565.8	3
Dome	4	120.72	563.21	15	120.72	563.21	4
Dome	5	152.9	559.7	15	152.9	559.7	5
Dome	6	184.14	555.34	15			
Dome	7	211.4	550.7	15	211.4	550.7	6
Dome	8	239.1	545.2	15	239.1	545.2	7
Dome	9	271.85	537.45	15			
Dome	10	306.63	527.68	15	306.63	527.68	8
Dome	11	316.22	524.68	15			
Dome	12	335.6	518.2	15	335.6	518.2	9
Dome	13	356.7	510.37	15			
Dome	14	371.86	504.24	15			
Dome	15	393.7	494.5	15	393.7	494.5	10
Dome	16	404.5	489.3	18.92			
Haunch	17	415.2	483.7	20.31			
Haunch	18	428.7	476.2	22.58	428.7	476.2	11
Haunch	19	441.8	468.2	25.56			
Haunch	20	454.5	459.5	29.46			
Haunch	21	469.9	447.4	36.36	469.9	447.4	12
Haunch	22	483.8	423.18	29.71			
Haunch	23	486.9	407.1	22.52	486.9	407.1	13
Haunch	24	488.47	393.5	19.07			
Wall	25	489	382.1	18	489	382.1	14
Wall	26	489	360.8	18			
Wall	27	489	345.6	18			
Wall	28	489	335	18	489	335	15
Wall	29	489	321	18			
Wall	30	489	306	18			
Wall	31	489	300	18			
Wall	32	489	281	18	489	281	16
Wall	33	489	260.5	18			
Wall	34	489	236	18	489	236.5	17
Wall	35	489	210.5	18			
Wall	36	489	201	18			
Wall	37	489	186.8	18	489	186.8	18
Wall	38	489	171	18			
Wall	39	489	150.5	18			
Wall	40	489	145.5	18	489	145.5	19
Wall	41	489	120.5	18			

Table 3-2. (contd)

	Section	Coordinates			ANSYS		
		R (inch)	**H (inch)**	**T (Inch)**	**X**	**Z**	**Set #**
Wall	42	489	100.5	18			
Wall	43	489	80	18			
Wall	44	489	60	18	489	70.0	20
Wall	45	489	39.9	18			
Wall	46	489	21	18	489	20	21
Wall	47	489	-4.5	18			
					489	-4.0	22
					531	-4.0	23
Slab	48	517	-18.4	23.5			
Slab	49	508.5	-18.4	23.5			
Slab	50	503	-18.4	23.5			
Slab	51	496.8	-19.1	23.5			
Slab	52	493	-19.1	23.5			
Slab	53	489	-19.1	22	489	-4.0	24
Slab	54	485.1	-19.1	22			
Slab	55	481	-19.1	22			
Slab	56	477	-19.1	22			
Slab	57	471	-19.1	22			
Slab	58	465	-19.1	22			
Slab	59	440	-19.1	19.38	438	-4.0	25
Slab	60	421.4	-17.9	17.05			
Slab	61	390	-15.9	13.12			
					410	-4.0	26
Slab	62	358	-13.9	9.13	358	-4.0	27
Slab	63	338	-13.4	8			
Slab	64	277.7	-13.4	8	277.7	-4.0	28
Slab	65	218.5	-13.4	8	218.5	-4.0	29
Slab	66	180	-13.4	8	180	-4.0	30
Slab	67	129.9	-13.4	8	129.9	-4.0	31
Slab	68	95.7	-13.4	8	95.7	-4.0	32
Slab	69	54	-17.1	15.43			
					36	-4.0	33
Slab	70	20	-20.1	21.5			
					0	-4.0	34
Note: The concrete tank wall is 8 inches short due to modeling error							

Element stiffnesses are also based on the TOLA model for Best Estimate concrete conditions for a maximum temperature of 250°F. Common properties for all concrete sections are provided below.

$\nu = 0.18$
Damping – 7%

Input file "Tank-Props-BEC-250.txt" defines the concrete tank material properties and real constants (thickness) for the Best Estimate concrete. Input file "Tank-Props-BEC-Crack.txt" defines the concrete tank material properties and real constants (thickness) for the Fully Cracked concrete. Table 3-3 provides a complete listing of section properties based on the TOLA model. Table 3-4 provides concrete section properties assuming all sections are cracked.

Table 3-3. Best Estimate Concrete Properites, 250°F

Cracked	Eshl	Shell Thickness t-shl		Shell Density, Rho-shl		M&D Section		PNNL Section
Y/N	(psi)	(ksf)	(in)	(ft)	(lb/in^3)	(lbf/ft^3)	No.	No.
N	4.502E+06	648,297	15.35	1.28	0.08484	147		1
N	4.352E+06	626,754	15.18	1.26	0.08578	148	1	2
N	4.306E+06	620,114	15.12	1.26	0.08609	149	2	3
N	4.282E+06	616,594	15.09	1.26	0.08627	149	3	4
N	4.262E+06	613,774	15.15	1.26	0.08595	149		5
N	4.243E+06	610,922	15.13	1.26	0.08609	149	4	6
N	4.315E+06	621,305	15.21	1.27	0.08559	148	5	7
N	4.295E+06	618,475	15.19	1.27	0.08572	148		8
N	4.216E+06	607,093	15.17	1.26	0.08583	148	6	9
N	4.201E+06	604,939	15.15	1.26	0.08594	148		10
N	4.439E+06	639,237	15.39	1.28	0.08463	146	7	11
N	4.425E+06	637,265	15.34	1.28	0.08487	147		12
N	4.405E+06	634,338	15.32	1.28	0.08497	147	8	13
N	4.392E+06	632,441	15.31	1.28	0.08504	147		14
N	4.316E+06	621,503	15.30	1.28	0.08510	147		15
N	4.406E+06	634,531	19.32	1.61	0.08499	147		16
N	4.366E+06	628,756	20.73	1.73	0.08505	147	9	17
N	4.323E+06	622,528	22.99	1.92	0.08527	147		18
Y	1.655E+06	238,350	26.72	2.23	0.08302	143		19
Y	1.345E+06	193,677	26.78	2.23	0.09548	165	10	20
N	4.000E+06	575,959	37.86	3.15	0.08337	144	11	21
N	3.960E+06	570,283	30.93	2.58	0.08339	144		22
Y	1.264E+06	182,025	21.60	1.80	0.09052	156		23
Y	1.409E+06	202,953	18.00	1.50	0.09197	159	12	24
Y	1.120E+06	161,221	15.28	1.27	0.10227	177		25
Y	1.093E+06	157,426	15.36	1.28	0.10170	176	13	26
Y	1.076E+06	155,010	15.42	1.28	0.10133	175		27
Y	1.068E+06	153,784	14.00	1.17	0.11163	193		28
Y	1.068E+06	153,784	14.00	1.17	0.11163	193		29
Y	1.068E+06	153,784	14.00	1.17	0.11163	193	14	30
Y	9.490E+05	136,651	13.53	1.13	0.11552	200		31
Y	9.490E+05	136,651	13.53	1.13	0.11552	200		32
Y	9.490E+05	136,651	13.53	1.13	0.11552	200	15	33
Y	9.490E+05	136,651	13.53	1.13	0.11552	200		34
Y	9.490E+05	136,651	13.53	1.13	0.11552	200	16	35
Y	9.490E+05	136,651	13.53	1.13	0.11552	200		36
Y	9.490E+05	136,651	13.53	1.13	0.11552	200		37
N	9.589E+05	138,084	14.89	1.24	0.10496	181	17	38
N	3.467E+06	499,310	18.08	1.51	0.08644	149		39
Y	3.435E+06	494,646	18.06	1.50	0.08652	150		40
Y	8.568E+05	123,378	12.89	1.07	0.12123	209	18	41
Y	8.568E+05	123,378	12.89	1.07	0.12123	209		42
Y	8.655E+05	124,633	14.21	1.18	0.10997	190	19	43
Y	8.655E+05	124,633	14.21	1.18	0.10997	190		44
Y	8.568E+05	123,378	12.89	1.07	0.12123	209		45
Y	8.638E+05	124,388	12.86	1.07	0.12149	210	20	46
Y	8.871E+05	127,746	14.12	1.18	0.11067	191		47
N	3.810E+06	548,683	23.64	1.97	0.09606	166	21	48
N	3.764E+06	542,010	23.65	1.97	0.09604	166		49
Y	1.038E+06	149,405	20.05	1.67	0.10680	185		50
Y	1.054E+06	151,733	20.06	1.67	0.10674	184		51
Y	1.075E+06	154,870	20.12	1.68	0.10643	184	22	52
Y	7.157E+05	103,055	14.04	1.17	0.13627	235		53

Table 3-3. (contd)

Cracked	Eshl	Shell Thickness t-shl		Shell Density, Rho-shl		M&D Section		PNNL Section
Y/N	(psi)	(ksf)	(in)	(ft)	(lb/in^3)	(lbf/ft^3)	No.	No.
N	3.571E+06	514,287	17.19	1.43	0.09959	172	23	54
N	3.570E+06	514,043	13.20	1.10	0.10383	179		55
Y	1.140E+06	164,113	6.14	0.51	0.16690	288	24	56
N	3.632E+06	522,946	7.94	0.66	0.11656	201	25	57
Y	1.349E+06	194,254	4.96	0.41	0.18649	322	26	58
Y	1.387E+06	199,783	7.02	0.58	0.16289	281	27	59
Y	1.129E+06	162,553	6.61	0.55	0.17280	299	28	60
Y	1.393E+06	200,531	5.01	0.42	0.22800	394	29	61
Y	1.163E+06	167,538	4.81	0.40	0.23765	411	30	62
Y	8.719E+05	125,560	12.28	1.02	0.14557	252		63

Table 3-4. Fully Cracked Concrete Properites

Is Section Cracked?	Eshl		Shell Thickness t-shl		Shell Density, Rho-shl		M&D Section	PNNL Section
	(psi)	(ksf)	(in)	(ft)	(lb/in^3)	(lbf/ft^3)	No.	No.
Y	1.435E+06	206,708	14.64	1.22	0.08893	154		1
Y	1.084E+06	156,131	13.21	1.10	0.09854	170	1	2
Y	9.438E+05	135,907	12.40	1.03	0.10504	182	2	3
Y	8.552E+05	123,148	11.78	0.98	0.11053	191	3	4
Y	9.951E+05	143,289	12.81	1.07	0.10168	176		5
Y	9.318E+05	134,181	12.41	1.03	0.10491	181	4	6
Y	1.141E+06	164,239	13.58	1.13	0.09590	166	5	7
Y	1.089E+06	156,781	13.32	1.11	0.09774	169		8
Y	1.029E+06	148,115	13.08	1.09	0.09951	172	6	9
Y	9.768E+05	140,657	12.53	1.04	0.10391	180		10
Y	1.512E+06	217,769	14.64	1.22	0.08897	154	7	11
Y	1.482E+06	213,340	14.39	1.20	0.09048	156		12
Y	1.443E+06	207,751	14.28	1.19	0.09119	158	8	13
Y	1.417E+06	204,062	14.20	1.18	0.09168	158		14
Y	1.371E+06	197,485	14.12	1.18	0.09219	159		15
Y	1.544E+06	222,339	18.42	1.53	0.08916	154		16
Y	1.474E+06	212,206	19.67	1.64	0.08962	155	9	17
Y	1.394E+06	200,772	21.66	1.81	0.09047	156		18
Y	1.531E+06	220,469	27.13	2.26	0.08177	141		19
Y	1.240E+06	178,532	27.37	2.28	0.09343	161	10	20
Y	1.046E+06	150,644	34.88	2.91	0.09050	156	11	21
Y	1.270E+06	182,924	32.31	2.69	0.07982	138		22
Y	1.163E+06	167,483	22.03	1.84	0.08873	153		23
Y	1.302E+06	187,438	18.31	1.53	0.09041	156	12	24
Y	1.028E+06	147,988	15.59	1.30	0.10025	173		25
Y	1.004E+06	144,559	15.67	1.31	0.09972	172	13	26
Y	9.887E+05	142,377	15.72	1.31	0.09937	172		27
Y	9.808E+05	141,234	14.29	1.19	0.10936	189		28
Y	9.808E+05	141,234	14.29	1.19	0.10936	189		29
Y	9.808E+05	141,234	14.29	1.19	0.10936	189	14	30
Y	8.690E+05	125,131	13.83	1.15	0.11297	195		31
Y	8.690E+05	125,131	13.83	1.15	0.11297	195		32
Y	8.690E+05	125,131	13.83	1.15	0.11297	195	15	33

Table 3-4. (contd)

Is Section Cracked?	Eshl		Shell Thickness t-shl		Shell Density, Rho-shl		M&D Section	PNNL Section
	(psi)	(ksf)	(in)	(ft)	(lb/in^3)	(lbf/ft^3)	No.	No.
Y	8.690E+05	125,131	13.83	1.15	0.11297	195		34
Y	8.690E+05	125,131	13.83	1.15	0.11297	195	16	35
Y	8.690E+05	125,131	13.83	1.15	0.11297	195		36
Y	8.690E+05	125,131	13.83	1.15	0.11297	195		37
Y	8.782E+05	126,463	15.21	1.27	0.10273	178	17	38
Y	8.690E+05	125,131	13.83	1.15	0.11297	195		39
Y	7.828E+05	112,717	13.20	1.10	0.11839	205		40
Y	7.828E+05	112,717	13.20	1.10	0.11839	205	18	41
Y	7.828E+05	112,717	13.20	1.10	0.11839	205		42
Y	7.908E+05	113,881	14.54	1.21	0.10747	186	19	43
Y	7.908E+05	113,881	14.54	1.21	0.10747	186		44
Y	7.828E+05	112,717	13.20	1.10	0.11839	205		45
Y	7.891E+05	113,629	13.17	1.10	0.11864	205	20	46
Y	8.104E+05	116,693	14.45	1.20	0.10813	187		47
Y	9.322E+05	134,235	21.54	1.79	0.10546	182	21	48
Y	9.324E+05	134,263	21.66	1.80	0.10488	181		49
Y	9.504E+05	136,857	20.46	1.71	0.10463	181		50
Y	9.659E+05	139,096	20.46	1.71	0.10465	181		51
Y	9.861E+05	141,998	20.52	1.71	0.10436	180	22	52
Y	6.510E+05	93,743	14.43	1.20	0.13263	229		53
Y	7.229E+05	104,097	14.13	1.18	0.12109	209	24	54
Y	8.420E+05	121,245	11.21	0.93	0.12227	211		55
Y	1.048E+06	150,866	6.25	0.52	0.16372	283	24	56
Y	1.147E+06	165,097	4.93	0.41	0.18777	324	25	57
Y	1.246E+06	179,441	5.05	0.42	0.18346	317	26	58
Y	1.283E+06	184,804	7.11	0.59	0.16072	278	27	59
Y	1.038E+06	149,438	6.73	0.56	0.16977	293	28	60
Y	1.288E+06	185,420	5.09	0.42	0.22441	388	29	61
Y	1.070E+06	154,101	4.90	0.41	0.23326	403	30	62
Y	7.964E+05	114,687	12.57	1.05	0.14218	246		63

Input file “Tank-Mesh1.txt” develops the concrete tank model. Element type SHELL143 is used for the concrete tank to be able to extract through-wall shear forces.

Figure 3-3 and Figure 3-4 show the profile and full concrete tank model, respectively.

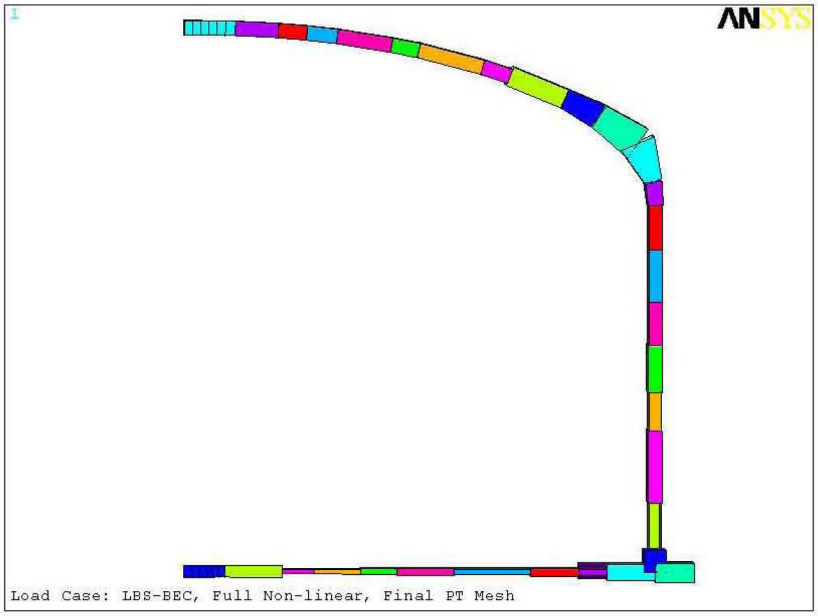


Figure 3-3. Concrete Tank Profile, Including Shell Thickness

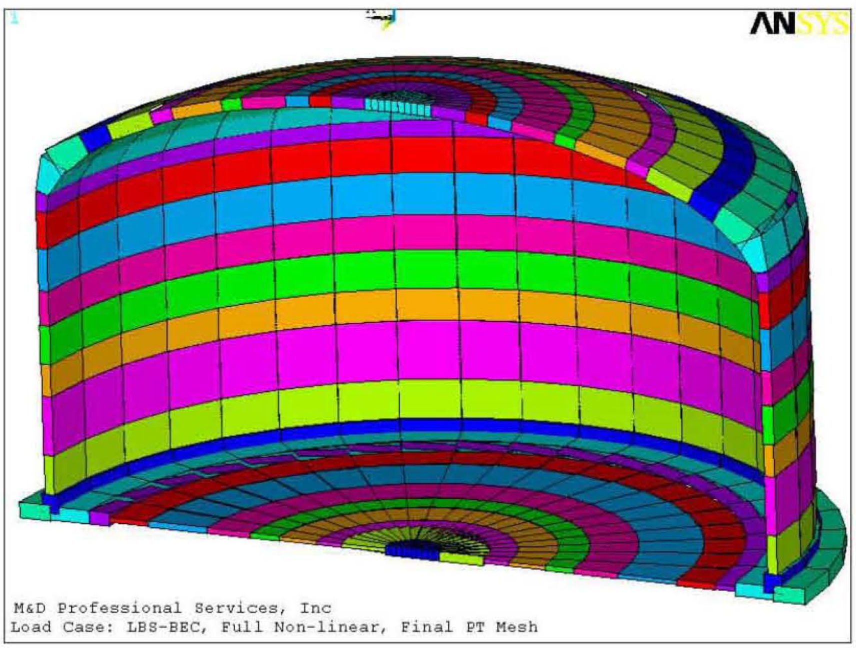


Figure 3-4. Concrete Tank Model Detail

3.2.3 Primary Tank

The geometry of the primary tank is based on drawing H-2-64449. To ensure that the anchor bolt elements are perpendicular to the primary tank, the primary tank dome coordinates were calculated based on the location of the corresponding concrete tank coordinate, taking into account the concrete shell thickness, and normal to the primary tank (See Figure 3-5). The concrete shell thickness used is based on the nominal concrete thickness.

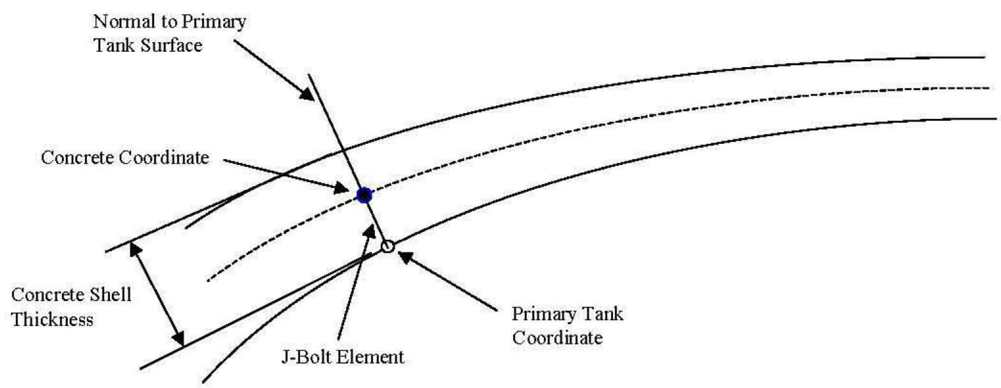


Figure 3-5. Primary/Concrete Tank Node Geometry

The location of the primary tank nodes were iteratively determined a follows:

Select a value for x (radial distance from center of the tank).

Calculate the respective location for y' based on the defined shape of the primary tank. The primary tank is an ellipse with a major axis of 80 ft and minor axis of 30 ft. The equation for location of y' is as follows:

$$y' = a\sqrt{1-\frac{x^2}{b^2}} - a, \text{ where} \tag{3.1}$$

$$a = \text{Minor Radius} = 180 \text{ in}$$

$$b = \text{Major Radius} = 480 \text{ in}$$

$$x = \text{Test Location for } x$$

$$\text{For } x = 61.0398, y' = 180\sqrt{1-\frac{61.0398^2}{480^2}} - 180 = -1.46 \tag{3.2}$$

The slope of the ellipse can be calculated by taking the derivative of the equation for y'.

$$\frac{d}{dx}\left(a\sqrt{1-\frac{x^2}{b^2}}\right) = -\frac{x\frac{a}{b}}{\sqrt{b^2-x^2}} \tag{3.3}$$

For x = 61.0398, the slope of the ellipse is –0.048. The corresponding angle is the arctangent of the slope, or in this case, -0.048. The length of line connecting the centerline of the concrete to the primary tank is half the thickness of the tank at that point. Therefore, to check the accuracy of the assumed x location of the primary tank, back-calculate the location of the concrete coordinates. If the back-calculated concrete location is the same as the known location, the x location of the primary tank must be correct, otherwise, reselect x until it is correct. The primary tank dome coordinate calculations are summarized in Table 3-5.

Following the example, for concrete location of (60.4), the x location of the primary tank is 61.0398. y' was determined to be –1.46. Adjusting this to value for the vertical location of the center of the ellipse, add 561.45 (elevation of the primary tank at the apex). For this case, y=559.99. The check is as follows:

$$X_{conc} = X_{primary} + \frac{t}{2}\sin(\theta),\ where\ \theta\ is\ the\ angle\ of\ the\ slope\ from\ horizontal \tag{3.4}$$

$$X_{conc} = 61.0398 + \frac{15}{2}\sin(0.048) = 61.39966 \approx 61.4 \tag{3.5}$$

$$Y_{conc} = Y_{primary} + \frac{t}{2}\cos(\theta) = 559.99 + \frac{15}{2}\cos(0.048) = 567.48136 \approx 567.5 \tag{3.6}$$

Table 3-5. Primary Tank Dome Coordination Calculation

Concrete				**Primary Tank**							
X	**y**	**T**	**Error**	**x**	**y**	**y'**	**Slope**	**Angle (rad)**	**Angle (Deg)**	**Y Offset**	**X Offset**
0	**568.95**	15	0%	**0**	561.45	0.00	0.000	0.000	0.000	7.500	0.000
30.2	568.6	15	0%	30.0238	561.10	-0.35	-0.024	-0.023	-1.346	7.498	-0.176
45	568.2	15	0%	44.7369	560.67	-0.78	-0.035	-0.035	-2.010	7.495	-0.263
61.4	567.5	15	0%	61.0398	559.99	-1.46	-0.048	-0.048	-2.753	7.491	-0.360
120.72	563.21	15	0%	119.9972	555.73	-5.72	-0.097	-0.097	-5.530	7.465	-0.723
152.9	559.7	15	0%	151.9685	552.19	-9.26	-0.125	-0.125	-7.134	7.442	-0.931
211.4	550.7	15	0%	210.0535	543.30	-18.15	-0.183	-0.181	-10.343	7.378	-1.347
239.1	545.2	15	0%	237.5336	537.86	-23.59	-0.214	-0.210	-12.055	7.335	-1.566
306.63	527.68	15	0%	304.4248	520.62	-40.83	-0.308	-0.298	-17.099	7.169	-2.205
335.6	518.2	15	0%	333.0513	511.07	-50.38	-0.361	-0.347	-19.866	7.054	-2.549
393.7	494.5	15	0%	390.2214	486.27	-75.18	-0.524	-0.482	-27.633	6.645	-3.479
428.7	476.2	22.58	0%	422.2643	467.04	-94.41	-0.694	-0.607	-34.752	9.276	-6.436
				432	459.91	-101.54	-0.774	-0.659	-37.750	0.000	0.000
				440	453.39	-108.06	-0.860	-0.710	-40.700	0.000	0.000
A	180										
B	480										

Element thicknesses are based on the drawing H-2-64449. General steel properties are used and are as follows:

Elastic Modulus (E) = 4,176,000 kip/ft^2
Poisson's Ratio (ν) = 0.30
Mass Density (ρ) = 0.001522 kip-sec^2/ft^4 = (0.490 kip/ft^3)/(32.2ft/sec^2)
Damping = 2%

Tank coordinates are developed in the model from input file "Tank-Coordinates-AY.txt." Tank element properties are from input file "Primary-Props-AY." The tank mesh is generated using "Primary.txt" and uses SHELL143 elements.

Figure 3-6 shows the full primary tank model and Figure 3-7 shows the detail in the knuckle region at the bottom of the tank.

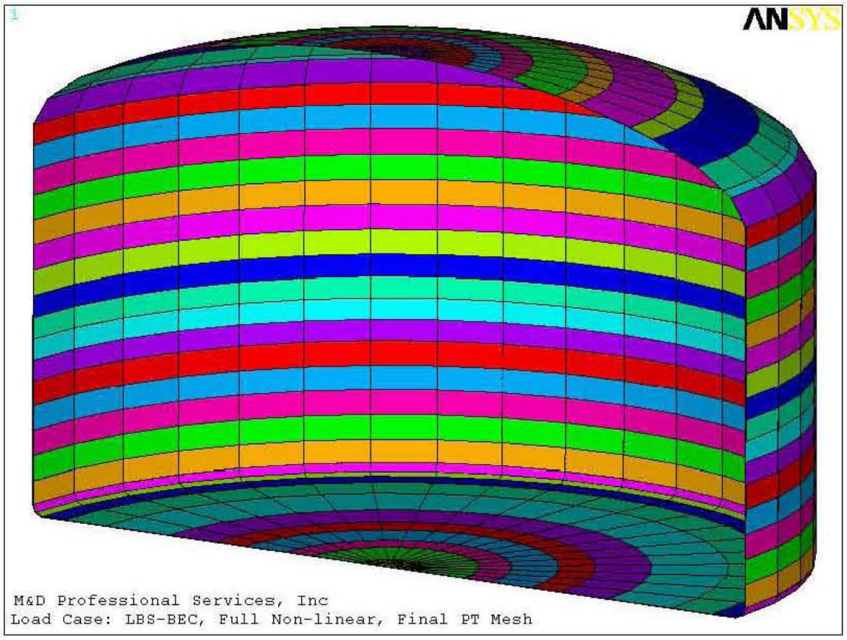


Figure 3-6. Primary Tank Model Detail

It was noted during checking that the overall height of the primary tank is 8 inches short. This does not affect the waste depth modeled (422 inches). Because the difference is small, it does not have a significant affect on the results and is therefore acceptable.

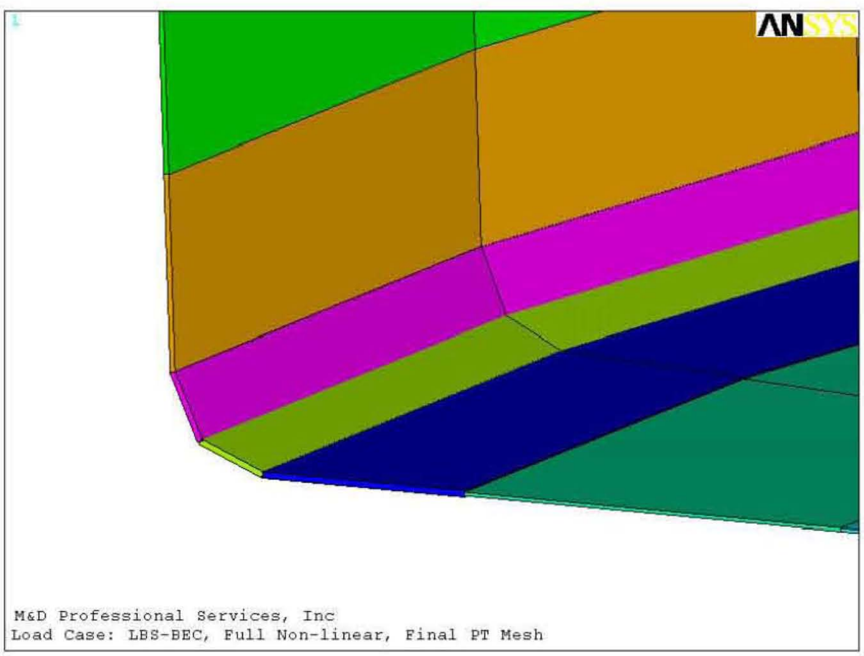


Figure 3-7. Primary Tank Model Detail – Knuckle Region

3.2.4 Insulating Concrete

The insulating concrete uses the geometry defined for the concrete and primary tanks and fills in the open volume with solid element (SOLID45). Concrete properties are taken as follows Rinker et al. (2004).

Elastic Modulus (E) = 23,760 kip/ft^2
Poisson's Ratio (ν) = 0.15
Mass Density (ρ) = 0.00155 kip-sec^2/ft^4 = (0.050 kip/ft^3)/(32.2ft/sec^2)
Damping = 7%

Material properties for the insulating concrete are in the file "Tank-Props-BEC-250.txt." The element mesh is generated using "Insulate.txt." Figure 3-8 shows the insulating concrete elements.

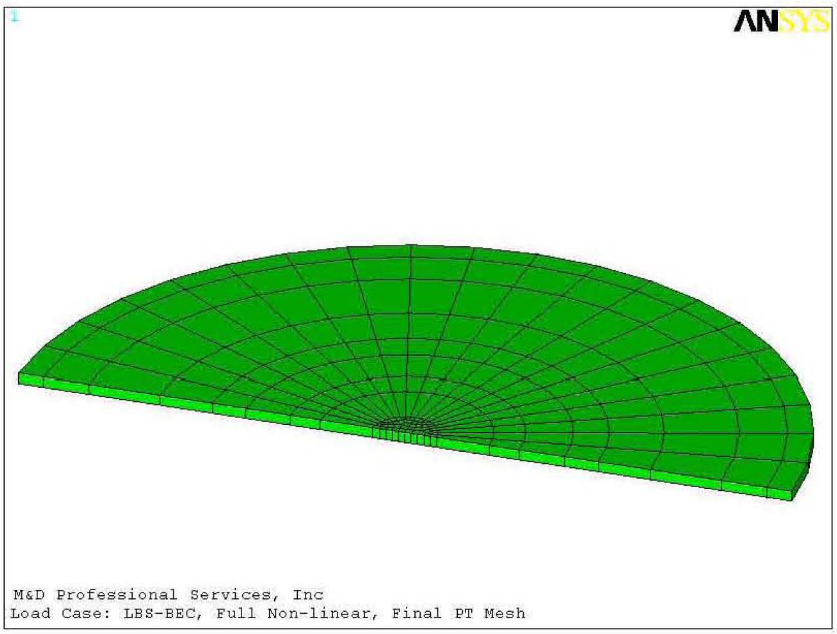


Figure 3-8. Insulating Concrete Model Detail

3.2.5 Anchor Bolts

The anchor bolts connecting the primary tank to the concrete shell are modeled using beam elements (BEAM4) and spring elements (COMBIN14). Based on drawing H-2-64310 the anchor bolts are spaced on an average of 2 ft in each direction. Therefore, the contributing area of the bolts in the model is based on the number of 4 ft^2 areas associated with the element. The required area is calculated based on the number of bolts to be represented and the thickness of the concrete at the bolt location. The anchor bolt area calculations are summarized in Table 3-6.

The BEAM4 elements are modeled as essentially rigid, and are oriented normal to the tank dome. Attached to the base of each beam element are three orthogonal springs oriented in the directions of the global coordinate system. Because the beams are rigid, the springs define the response of the anchor bolts in the model.

Table 3-6. Anchor Bolt Area Calculation

Ring No.	1	2	3	4	5	6	7	8	9	10	11
X	0.00	44.72	89.87	120.00	151.97	210.05	237.53	304.42	333.05	390.22	422.26
Y	561.45	560.77	558.37	555.83	552.29	543.40	537.96	520.72	511.17	486.37	467.14
Apex ΔY	0.00	0.68	3.08	5.62	9.16	18.05	23.49	40.73	50.28	75.08	94.31
Delta Y	0.00	0.68	2.40	2.53	3.54	8.89	5.43	17.25	9.55	24.80	19.23
x'	0.00	44.72	89.92	120.13	152.24	210.83	238.69	307.14	336.83	397.38	432.67
X"	0.00	44.72	89.93	120.17	152.34	211.10	239.11	308.19	338.37	400.69	438.06
Horizontal Midpoint	22.36	67.33	105.05	136.26	181.72	225.11	273.65	323.28	369.53	419.37	443.88
Ring Area	785.52	6335.32	10214.81	11827.27	22708.34	27726.13	38033.10	46534.03	50329.54	61766.66	41420.22
Number of Bolts in Ring	1.36	11.00	17.73	20.53	39.42	48.14	66.03	80.79	87.38	107.23	71.91
Bolts per element (20 Sections)	1.36	0.55	0.89	1.03	1.97	2.41	3.30	4.04	4.37	5.36	3.60

The baseline model encompasses the DSTs from the AN, AW, AY, AZ, and SY Tank Farms. The approach to the baseline model is that it should represent a Lower-Bound configuration for the tank farms listed above. However, in the case of anchor bolts, it is not clear a priori what represents a conservative or non-conservative configuration. Consequently, a range of anchor bolt properties will be used to represent the variation across the different tank farms. The most significant variable affecting the shear response of the anchor bolts is the concrete compressive strength. The anchor configurations for the DST Farms are summarized in Table 3-7. For the AN, AW, AY, AZ, and SY Tank Farms represented by the baseline model, both J- and L-configurations of hooked anchors are present, and the minimum 28-day concrete compressive strengths range from 3 to 5 ksi.

Table 3-7. Summary of Anchor Configuration for DST Farms.

Tank Farm	Concrete 28-Day Minimum Compressive Strength (ksi)	Anchor Bolt Configuration
AN	4.5	L-bolt
AP	5	Headed stud
AW	5	L-bolt
AY	3	J-bolt
AZ	3	J-bolt
SY	4.5	J-bolt

Common to all the tanks is the use of a 3/4 inch external diameter by 1-3/8 inch long internally threaded weld stud (Nelson TBL shown in Figure 3.9, except that AY tank drawings call out a TPF stud) that is welded onto the steel tank or liner. The 1/2 inch anchor bolt, whether J, L, or headed stud is then threaded into this stud.

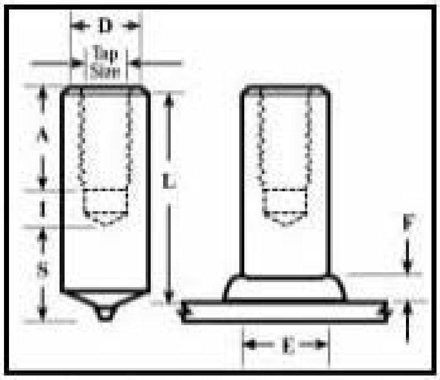


Figure 3-9. Nelson Internally Threaded Stud

The development of the shear stiffnesses used to represent that anchor bolt response for the baseline model is discussed in detail in Appendix D. The most significant points are as follows:

- The shear behavior of the hooked anchors is assumed to be represented by test data for headed studs of the same diameter.
- The shear response of J- and L-bolts is assumed to be the same.
- The effect of the tapped base is determined by a detailed finite element model of the anchor as described in Deibler et al. (2008), Appendix B.
- The effect of concrete compressive strength on the anchor shear response is based on test data as described in Appendix D.
- To account for the age-hardened condition of the concrete, the estimated shear stiffnesses for the anchors is based on concrete compressive strengths of 4 to 8 ksi.
- The Lower-Bound shear stiffness for the anchors is estimated to be 47 kip/in, and is based on 4 ksi concrete.
- The Upper-Bound shear stiffness for the anchors is estimated to be 90 kip/in, and is based on 8 ksi concrete.
- The case of a Fully-Cracked section is addressed by reducing the shear stiffness to 23.5 kip/in, or 50% of the estimated lower-bound value. The allowable shear displacements for the Fully-Cracked case are approximately 180% of the Lower-Bound values.

The response of the anchor bolts to tensile loads was based on test data provided in Nelson (1961). The data included tensile load-deformation curves for ½-in. diameter bent stud anchors. The data showed that for the range of deformations experienced in this analysis, a typical secant axial modulus was of similar magnitude as the secant shear moduli established using the methodology outlined in the previous section and described in detail in Appendix D. For this reason, the axial stiffness of the anchor bolts was selected to be the same as the shear stiffness. The bolts were assigned the same properties independent of radial position, which leads to conservative predictions of displacement.

The combinations of bolt secant modulus and concrete and soil properties lead to the following run matrix:

Table 3-8. Anchor Bolt Area Calculation

Secant Modulus	Concrete and Soil Properties			
	BES-BEC	UBS-BEC	LBS-BEC	BES-FCC
Best-Estimate	No	No	No	No
Lower Bound	Yes	Yes	Yes	Yes
Upper Bound	Yes	No	No	No
Fully-cracked	Yes	No	No	No

The anchor bolt model is developed using input file "Bolts-Friction.txt." See Figure 3-10 for the distribution of anchor bolts. Figure 3-11 shows the locations of spring elements connecting the end of each anchor bolt to the primary tank.

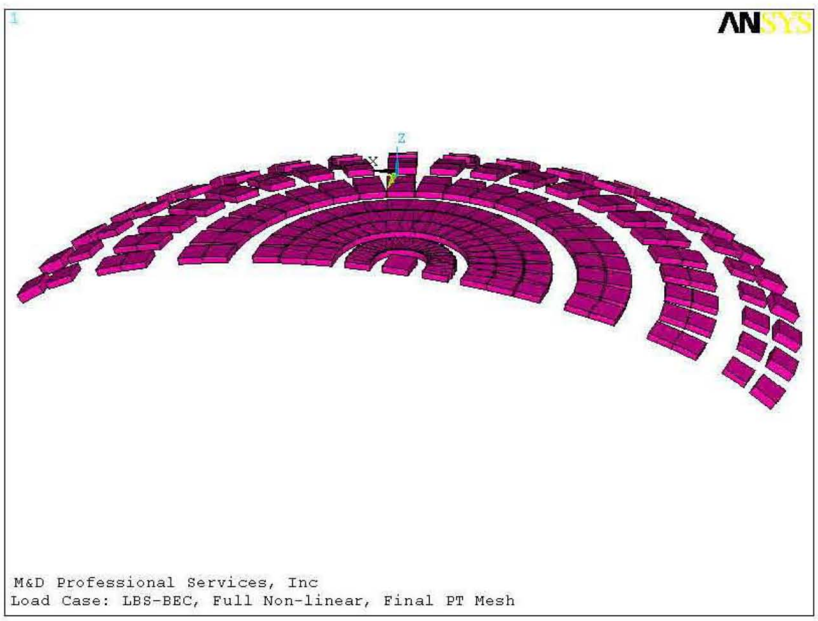


Figure 3-10. Anchor Bolt Model Detail

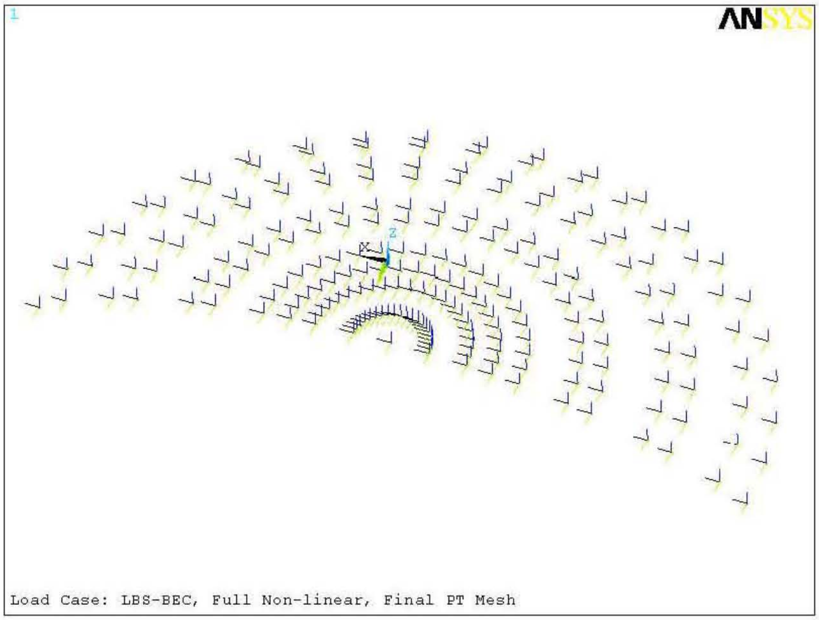


Figure 3-11. Spring Elements – Anchor Bolts to Primary Tank

3.2.6 Secondary Liner

The secondary liner is modeled using SHELL143 elements and its geometry is taken from H-2-64449. The steel thickness is 0.25 inch throughout the liner. The model stops after the 1st full wall element coincident with the liner. The secondary liner is shown in Figure 3-12.

Input file "Liner.txt" develops the model for the liner using the geometry defined for the concrete tank in "Tank-Coordinates.txt." The following material properties are used for the steel liner.

Elastic Modulus (E) =4,176,000 kip/ft^2
Poisson's Ratio (ν) = 0.30
Mass Density (ρ) = 0.001522 kip-sec^2/ft^4 = (0.490 kip/ft^3)/(32.2ft/sec^2)
Damping = 2%

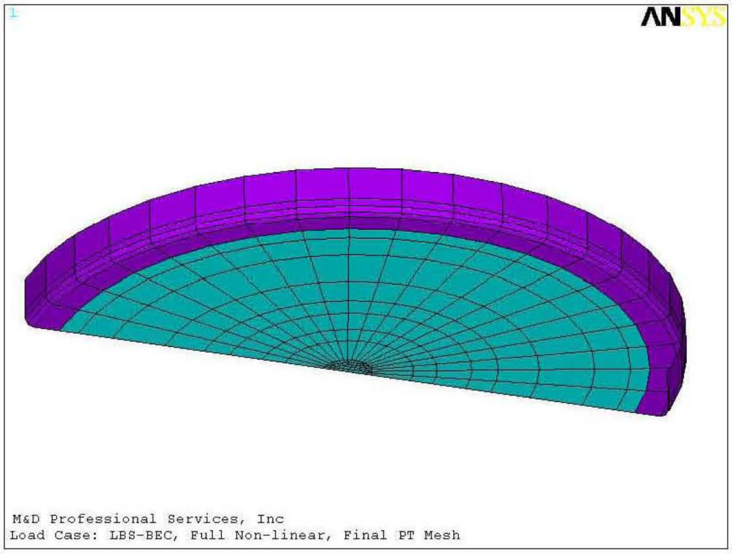


Figure 3-12. Secondary Liner Model Detail

3.2.7 Waste

The waste is modeled using solid elements (SOLID45) with material properties defined to emulate a liquid. The waste elements are meshed such that there are no common nodes with the primary tank; however, those on the exterior (at the primary tank) are coincident with the primary tank nodes. Contact elements are used for the interface between the waste and the primary tank. The material properties are as follows:

Elastic Modulus (E) = 25.92 kip/ft^2
Poisson's Ratio (ν) = 0.4999
Mass Density (ρ) = 0.003294 kip-sec^2/ft^4 = (1.7*0.0624 kip/ft^3)/(32.2ft/sec^2)
Damping = 0
Shear Modulus (G) = 0.216 kip/ft^2

E was calculated based on the Bulk Modulus of water (~300,000 psi). Using a value of ν close to 0.5 (0.4999), the value of E can be calculated.

$$\mathrm{B} = E/[3(1-2\nu)]\ or \tag{3.10}$$

$$E = \mathrm{B}[3(1-2\nu)] = 300{,}000[3(1-2(0.4999))] = 180 lb/in^2 = 25.92 kip/ft^2 \tag{3.11}$$

G can then be calculated based on E and ν, G=E/[2(1+ν)]. For the values shown above, this gives a value for G of 8.64 kip/ft^2. However, because a fluid cannot carry shear, a smaller value is used. The value was selected such that the solution remains mathematically stable.

Figure 3-13 shows the waste elements.

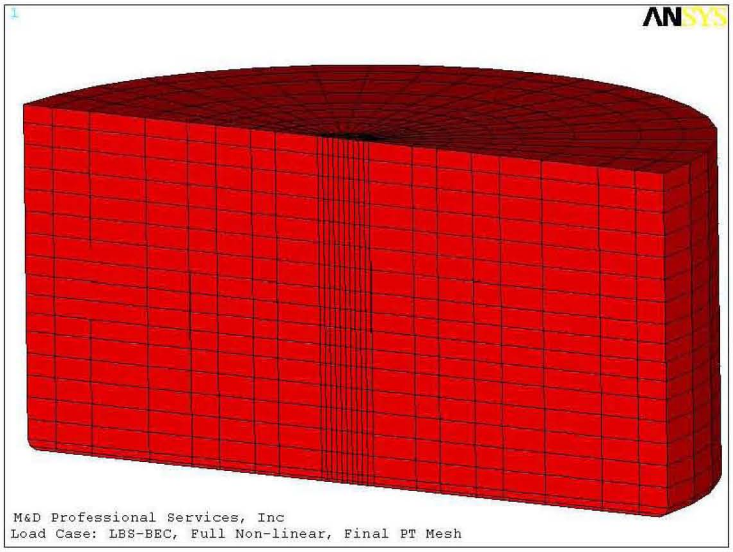


Figure 3-13. Waste Model Detail

Two benchmarking studies were performed to assess the fluid-structure interaction behavior of the primary tank and contained waste under seismic excitation. In the study documented in Rinker et al. (2006b), the fluid-structure interaction was simulated in ANSYS®. In the study documented in Rinker and Abatt (2008a), the fluid-structure interaction was simulated using Dytran®. The studies showed that the modeling approach used in ANSYS® adequately predicts the total hydrodynamic reaction force and pressure distribution both vertically and circumferentially, but that the model was deficient in predicting the convective response of the waste. In particular, the maximum slosh height is not well characterized, under-predicting the maximum displacement by a factor of three.

3.2.8 Primary Tank/Concrete Dome Interface

A combination of TARGE170 and CONTA173 elements are used to model the interface between the top of the primary tank and the inside face of the concrete dome. Key-Option controls are used to place the interface location at the inside face of the concrete (or bottom of the concrete shell element). A coefficient of friction of 0.01 was used for the contact surface.

The contact surface is developed using input file "bolts-friction.txt." Figure 3.14 shows the contact and target elements comprising the dome contact surface.

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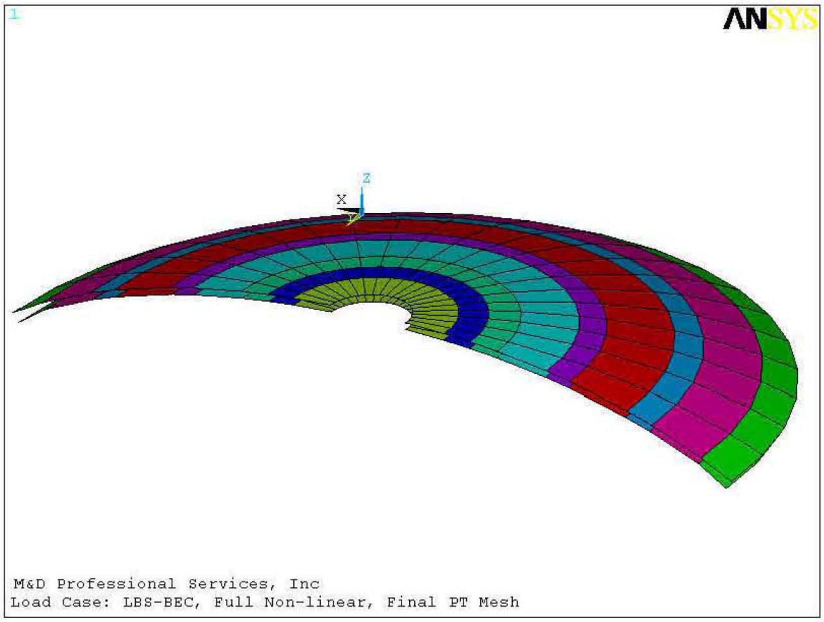

Figure 3-14. Contact Elements – Primary Tank to Concrete Dome

3.2.9 Primary Tank/Insulating Concrete Interface

A combination of TARGE170 and CONTA173 elements are used to model the interface between the bottom of the primary tank and the top of the insulating concrete. The contact and target surfaces are modeled as coincident (i.e., no offsets are included for shell thicknesses). A coefficient of friction of 0.4 was used for the contact surface. The contact surface is developed using input file "interface1.txt." See Figure 3-15 shows the contact elements (Top layer of elements)

3.2.10 Insulating Concrete/Secondary Liner Interface

A combination of TARGE170 and CONTA173 elements are used to model the interface between the bottom of the primary tank and the top of the insulating concrete. The contact and target surfaces are modeled as coincident (i.e., no offsets are included for shell thicknesses). A coefficient of friction of 0.4 was used for the contact surface. The contact surface is developed using input file "interface1.txt." See Figure 3-16 shows the contact elements (Bottom layer of elements).

3.2.11 Soil/Concrete Tank Interface

A combination of TARGE170 and CONTA173 elements are used to model the interface between the soil and the concrete tank, and for the interface plane between the native and excavated soils. A coefficient of friction of 0.2 was used for the contact surface during the gravity solution phase (static case), and then changed to 0.6 for the transient portion of the solution. See Figure 3-16 for the contact surface model.

For the interface between the bottom of the footing and the native soil, COMBIN14 (spring) elements were used. An arbitrary, high, stiffness values was applied to these springs. See Figure 3-17.

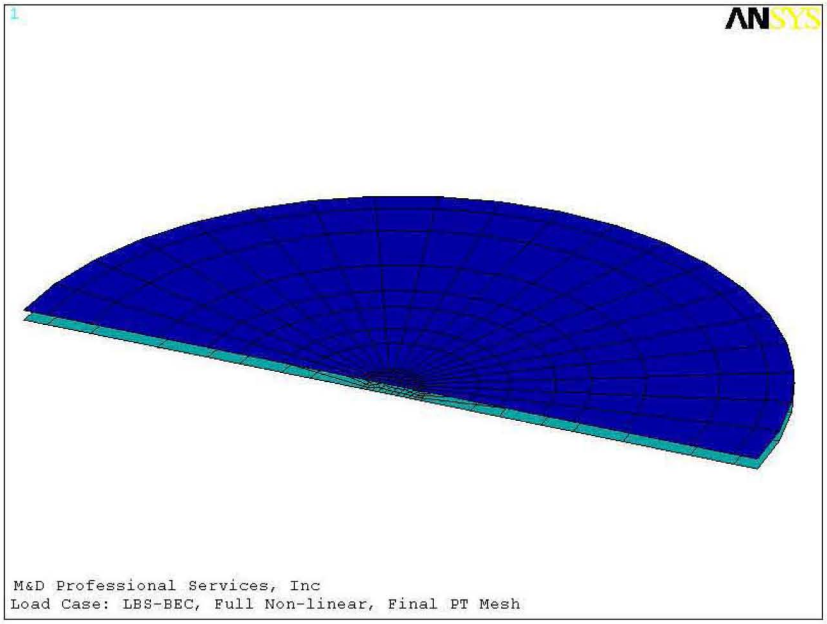

Figure 3-15. Contact Elements –Insulating Concrete Top and Bottom

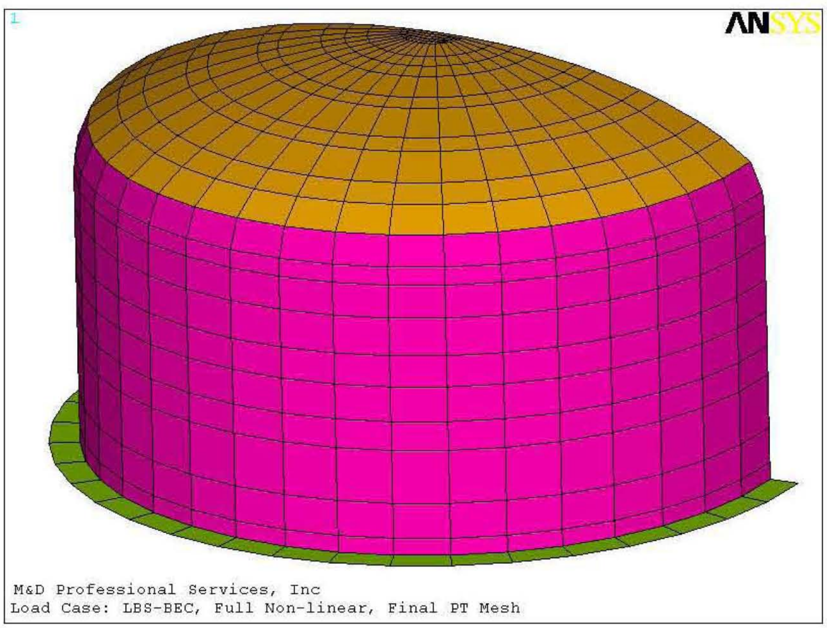

Figure 3-16. Contact Elements – Soil to Concrete Tank

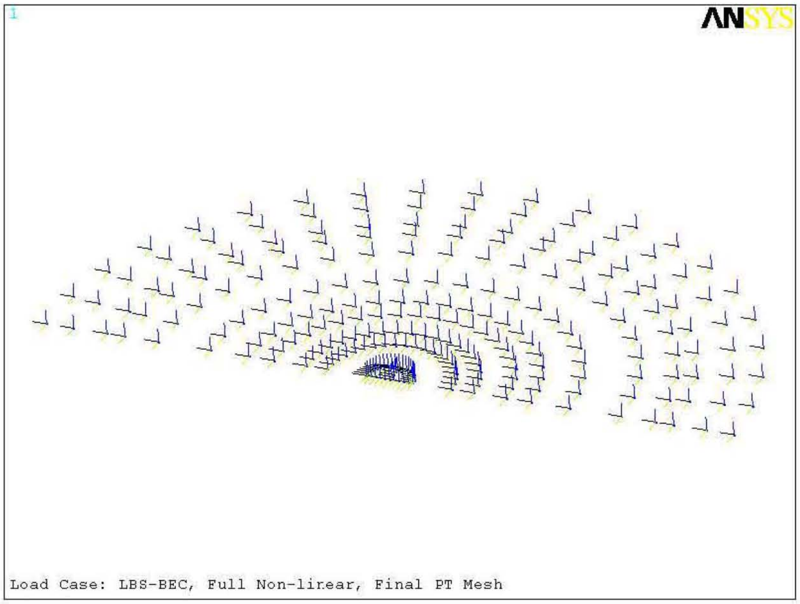

Figure 3-17. Spring Elements – Concrete Footing to Soil

3.2.12 Excavated/Native Soil Interface

A combination of TARGE170 and CONTA173 elements are used to model the interface between the native and excavated soils. An initial coefficient of friction of 0.3 is used for the gravity (static) analysis. The coefficient of friction is changed to 0.7 for the transient analysis. This surface is included to improve the initial conditions for the transient analysis by allowing an initial displacement between the native and excavated soil. Figure 3-18 shows the contact elements constituting the soil interface.

This surface is developed using the input file “fix-soil.txt”

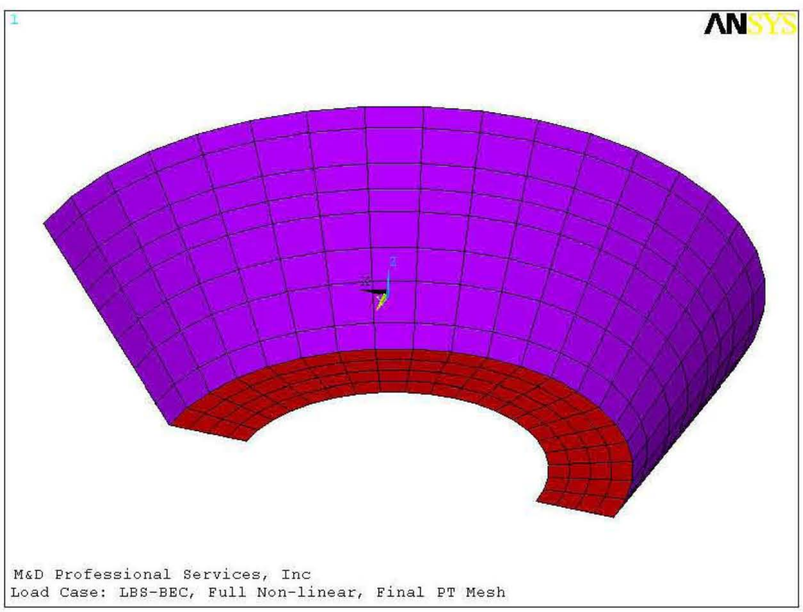

Figure 3-18. Contact Elements – Near Soil to Far Soil

3.2.13 Waste/Primary Tank Interface

A combination of TARGE170 and CONTA173 elements are used to model the interface between waste and primary tank. No friction is included for this surface. A high stiffness was defined for this contact to obtain the correct hydrostatic pressure on the tank. The high stiffness of the contact was needed because the waste model was very soft. Excessive displacements occur without modifying the contact stiffness. The contact surface is developed using input file "Waste-Solid-AY.txt." The interface between the waste and primary tank is shown in Figure 3-19.

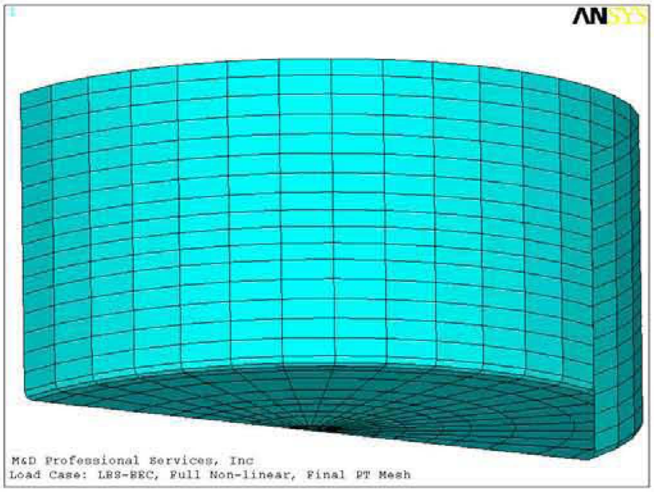

Figure 3-19. Contact Elements – Waste to Primary Tank

3.2.14 Concrete Wall/Footing Interface

The contact at the bottom of the wall was modeled using CONTA178 elements. A friction coefficient of 0.2 was used for this contact to reflect the steel on steel interface. Use of contact elements for this interface will be used to establish if displacement can occur during a seismic event, and allows only normal and shear forces to be transferred to the footing. The contact between the bottom of the wall and the footing is shown in Figure 3-20.

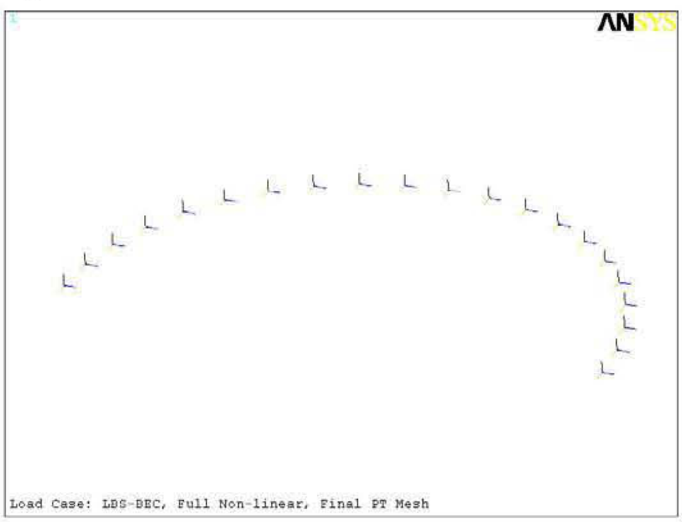

Figure 3-20. Contact Elements – Concrete Wall to Footing

3.2.15 Surface Loads

MASS21 elements were added to the soil surface over the center of the dome to create a "live load" over the tank dome. The mass provides an equivalent weight of 200,000 lbf. Mass elements were used in lieu of forces to capture the dynamic participation of equipment that creates this load. Figure 3-21 illustrates the placement of the mass elements.

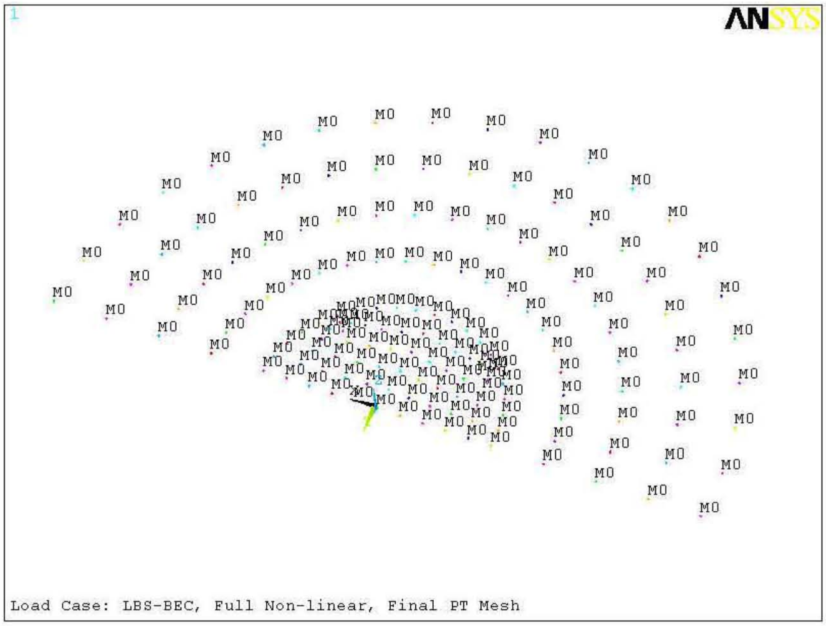

Figure 3-21. Mass Elements – Soil Surface

3.3 Soil Model

This section describes the geometry and construction of the ANSYS® finite element model of the soil surrounding the DST. A comprehensive description of the FE model is found in the Seismic Analysis report (Abatt and Rinker. 2008). The Seismic Analysis report should be referenced for complete model description and background information.

3.3.1 Soil Properties

The soil surrounding the tank is modeled in two groups, the excavated soil, and the far-field soil. The excavated soil fills the volume outside the concrete tank and bounded by the slope matching the soil removed during construction. The far-field soil is comprised of all other soil out to a radius of 320 ft and a depth of 266 ft. Both regions are modeled using SOLID45 elements.

Two SHAKE analyses were performed for each soil condition to obtain soil properties for the layering used in the model (Rinker el al. 2006a). One run used the native soil properties and is used for the far-field soil material properties. The second run used material properties associated with structural backfill and the results are used for the material properties in the excavated soil region.

Soil properties used for the model are listed in the following Tables:

- Table 3-9. **Best Estimate Native Soil Iterated Soil Properties**

- Table 3-10. **Best Estimate Excavated Soil Iterated Soil Properties**
- Table 3-11. **Upper Bound Native Soil Iterated Soil Properties**
- Table 3-12. **Upper Bound Excavated Soil Iterated Soil Properties**
- Table 3-13. **Lower Bound Native Soil Iterated Soil Properties**
- Table 3-14. **Lower Bound Excavated Soil Iterated Soil Properties**

Table 3-9. Best Estimate Native Soil Iterated Soil Properties

Layer Depth	Damping	G	Poisson's Ratio	E	Density	Material Property No.
2.5	0.017	6622.3	0.24	16,423	110	901
9.2	0.025	6241.7	0.24	15,479	110	902
16.4	0.034	5839.1	0.24	14,481	110	903
22.1	0.028	5930.4	0.24	14,707	110	904
29	0.032	5724.9	0.19	13,625	110	905
37.2	0.033	6494.2	0.19	15,456	110	906
44.7	0.033	7366.4	0.19	17,532	110	907
52.9	0.025	8811.9	0.19	20,972	110	908
65.5	0.026	9851.5	0.19	23,447	110	909
82	0.027	9721.9	0.19	23,138	110	910
98.8	0.029	9560.1	0.19	22,753	110	911
115.5	0.033	9272.5	0.19	22,069	110	912
132	0.025	10831.8	0.19	25,780	110	913
148.3	0.027	10644	0.19	25,333	110	914
167.5	0.022	13867.4	0.28	35,501	120	915
189.5	0.021	15416	0.28	39,465	120	916
211.5	0.023	15064.3	0.28	38,565	120	917
233.5	0.025	14732.5	0.28	37,715	120	918
255.5	0.024	16209.2	0.28	41,496	120	919

Table 3-10. Best Estimate Excavated Soil Iterated Soil Properties

Layer Depth	Damping	G	Poisson's Ratio	E	Density	Material Property No.
2.5	0.019	3920.4	0.27	9,958	125	801
9.2	0.035	3463.4	0.27	8,797	125	802
16.4	0.048	3088.5	0.27	7,845	125	803
22.1	0.039	3231.8	0.27	8,209	125	804
29	0.048	3005.6	0.27	7,634	125	805
37.2	0.055	2829.8	0.27	7,188	125	806
44.7	0.059	2729.6	0.27	6,933	125	807
52.9	0.045	3018.4	0.27	7,667	125	808

Table 3-11. Upper Bound Native Soil Iterated Soil Properties

Layer Depth	Damping	G	Poisson's Ratio	E	Density	Material Property No.
2.5	0.016	10004.3	0.24	24,811	110	901
9.2	0.022	9607.3	0.24	23,826	110	902
16.4	0.027	9268.4	0.24	22,986	110	903
22.1	0.022	9383.3	0.24	23,271	110	904
29	0.026	9068.8	0.19	21,584	110	905
37.2	0.027	10289.2	0.19	24,488	110	906
44.7	0.028	11649.1	0.19	27,725	110	907
52.9	0.022	13709.7	0.19	32,629	110	908
65.5	0.022	15284.2	0.19	36,376	110	909
82	0.024	15035.4	0.19	35,784	110	910
98.8	0.025	14863.1	0.19	35,374	110	911
115.5	0.026	14746.3	0.19	35,096	110	912
132	0.02	16982.4	0.19	40,418	110	913
148.3	0.021	16838.8	0.19	40,076	110	914
167.5	0.019	21821.5	0.28	55,863	120	915
189.5	0.019	23910.6	0.28	61,211	120	916
211.5	0.02	23673.5	0.28	60,604	120	917
233.5	0.02	23525	0.28	60,224	120	918
255.5	0.019	25917.8	0.28	66,350	120	919

Table 3-12. Upper Bound Excavated Soil Iterated Soil Properties

Layer Depth	Damping	G	Poisson's Ratio	E	Density	Material Property No.
2.5	0.017	5956.9	0.27	15,131	125	801
9.2	0.027	5554.3	0.27	14,108	125	802
16.4	0.039	5041.9	0.27	12,806	125	803
22.1	0.031	5191.5	0.27	13,186	125	804
29	0.035	5005.7	0.27	12,714	125	805
37.2	0.042	4747.8	0.27	12,059	125	806
44.7	0.047	4551.9	0.27	11,562	125	807
52.9	0.037	4864.9	0.27	12,357	125	808

Table 3-13. Lower Bound Native Soil Iterated Soil Properties

Layer Depth	Damping	G	Poisson's Ratio	E	Density	Material Property No.
2.5	0.018	4382.9	0.24	10,870	110	901
9.2	0.03	4004	0.24	9,930	110	902
16.4	0.043	3590.3	0.24	8,904	110	903
22.1	0.034	3739.6	0.24	9,274	110	904
29	0.04	3551.3	0.19	8,452	110	905
37.2	0.042	4004.4	0.19	9,530	110	906
44.7	0.042	4561.5	0.19	10,856	110	907
52.9	0.03	5629.7	0.19	13,399	110	908
65.5	0.03	6331	0.19	15,068	110	909
82	0.035	6066.4	0.19	14,438	110	910
98.8	0.039	5831.4	0.19	13,879	110	911
115.5	0.043	5633.7	0.19	13,408	110	912
132	0.032	6786.7	0.19	16,152	110	913
148.3	0.032	6763.3	0.19	16,097	110	914
167.5	0.028	8619.5	0.28	22,066	120	915
189.5	0.028	9445.3	0.28	24,180	120	916
211.5	0.029	9314.8	0.28	23,846	120	917
233.5	0.029	9320.7	0.28	23,861	120	918
255.5	0.026	10588.1	0.28	27,106	120	919
279	0.014	29929.7	0.3	77,817	125	920
304	0.014	29856.3	0.3	77,626	125	921
329	0.015	29714.3	0.3	77,257	125	922
354	0.015	29602.2	0.3	76,966	125	923

Table 3-14. Lower Bound Excavated Soil Iterated Soil Properties

Layer Depth	Damping	G	Poisson's Ratio	E	Density	Material Property No.
2.5	0.023	2547.2	0.27	6,470	125	801
9.2	0.044	2126.7	0.27	5,402	125	802
16.4	0.066	1782.2	0.27	4,527	125	803
22.1	0.053	1910.9	0.27	4,854	125	804
29	0.061	1777	0.27	4,514	125	805
37.2	0.067	1689.3	0.27	4,291	125	806
44.7	0.07	1628.4	0.27	4,136	125	807
52.9	0.056	1815.9	0.27	4,612	125	808

3.3.2 Excavated Soil

The excavated soil portion of the soil is developed using the input file "Near-Soil-1.txt." Figures 3-22 through 3-24 show the detail of the excavated region of soil. The development of the softened regions of the soil over the tank dome is discussed in detail in the Seismic Analysis report (Abatt and Rinker 2008).

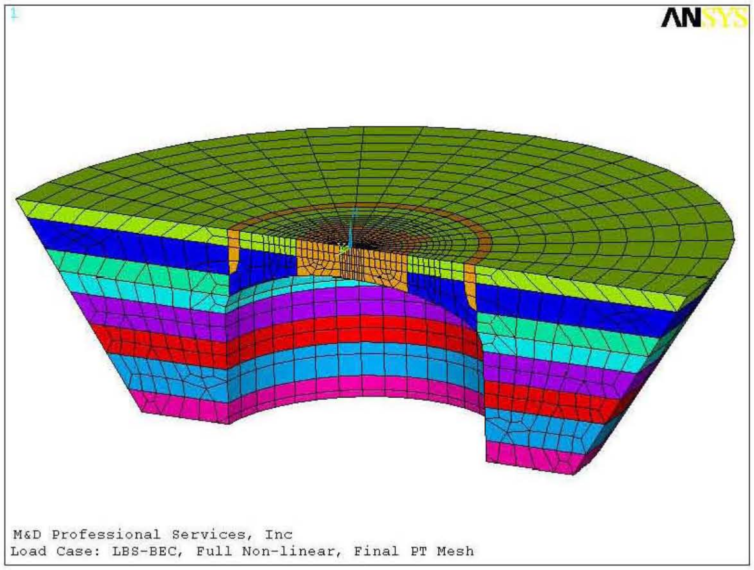

Figure 3-22. Excavated Soil Model Detail

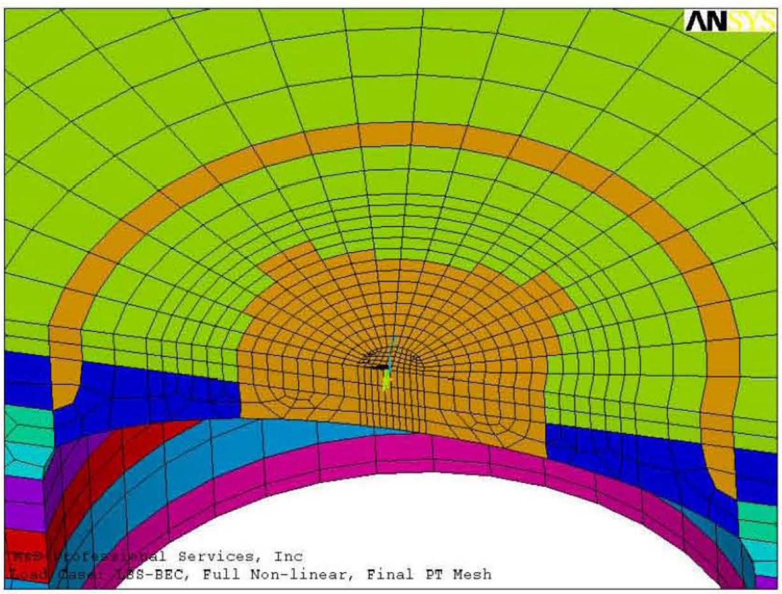

Figure 3-23. Excavated Soil – Softened Soil Zones

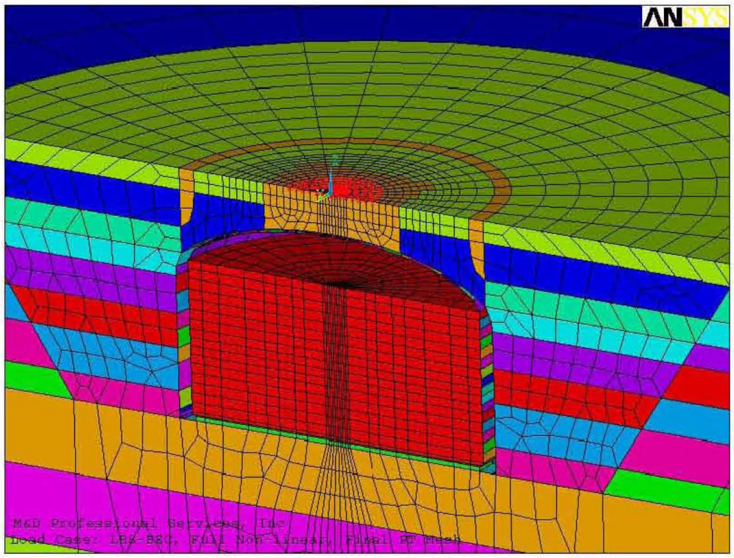

Figure 3-24. Model Detail

3.3.3 Native Soil

The native soil region of the model is developed using input file "Far-Soil.txt." SOLID45 elements are used and the material properties are discussed above.

Figure 3-25 shows the native soil portion of the model.

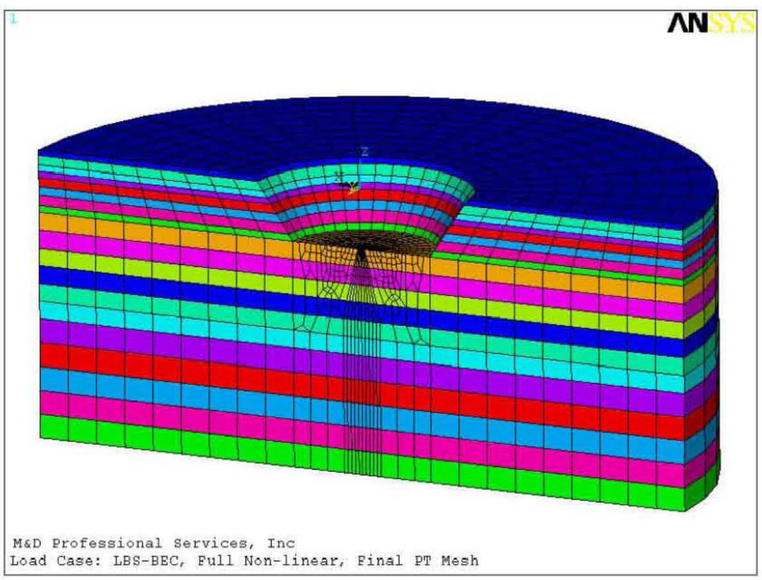

Figure 3-25. Far-Field Soil Model Detail

LINK8 elements are used to connect the native soil slaved nodes on each layer to the symmetry plane. These are required because the slaved node of a couple cannot have a boundary condition applied to it. Therefore, to maintain the desired soil behavior, the link elements effectively complete the coupling of the outside soil node at each layer. Figure 3-26 shows the locations of the link elements. Input file "Outer-Spar.txt" develops these elements.

Figure 3-26. Link Elements – Edges of Soil Model

3.4 Boundary Conditions

This section describes the boundary conditions applied to the ANSYS® seismic finite element model. A comprehensive description of the FE model is found in the Seismic Analysis report (Carpenter et al. 2006). The Seismic Analysis report should be referenced for complete model description and background information.

3.4.1 Soil Boundary Conditions

All nodes on the outside edge (radius = 320 ft) have been "slaved" to a single node at each layer. Couples are used in each of the three translations to force the soil to behave essentially as a shear beam. This approach is used to create the appropriate conditions for vertical and horizontal waves to pass through the model (see Figure 3-28 and Figure 3-29). The effectiveness of this approach is documented in Rinker et al. (2006a). All nodes on the bottom of the model (-266 ft) are coupled together to create a rigid foundation (see Figure 3-27).

The symmetry plane for the soil has all nodes fixed for Y translation, see Figure 3-30.

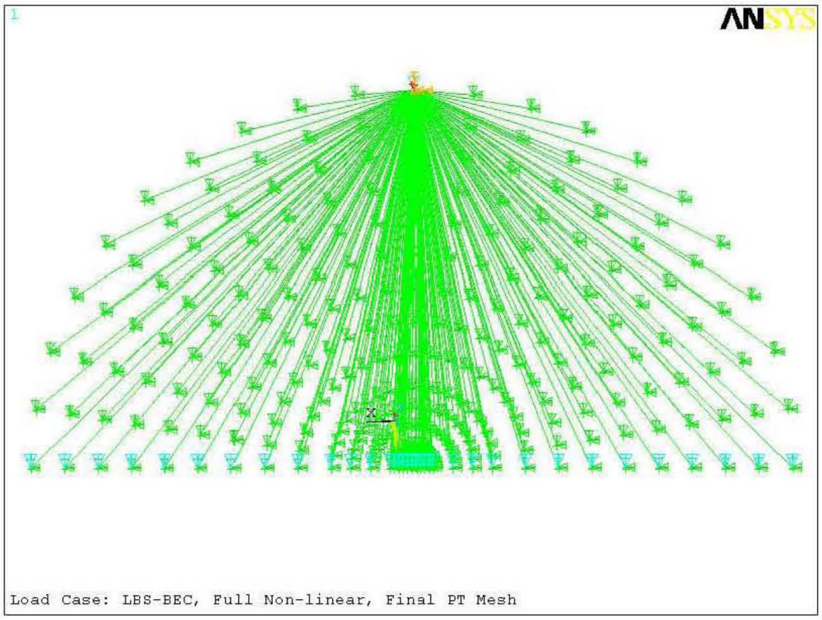

Figure 3-27. Boundary Conditions - Soil Base

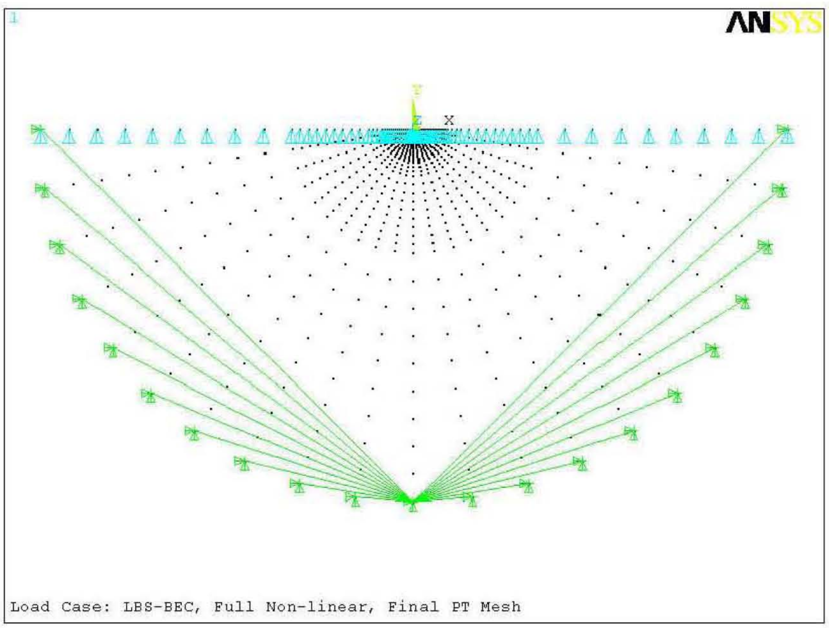

Figure 3-28. Boundary Conditions – Typical Soil Layer

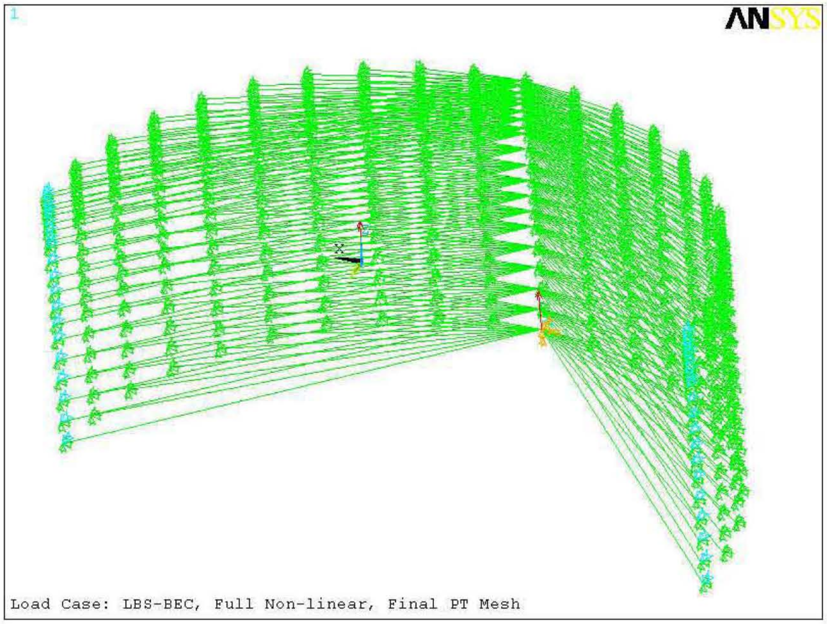

Figure 3-29. Boundary Conditions – Slaved Boundary Conditions

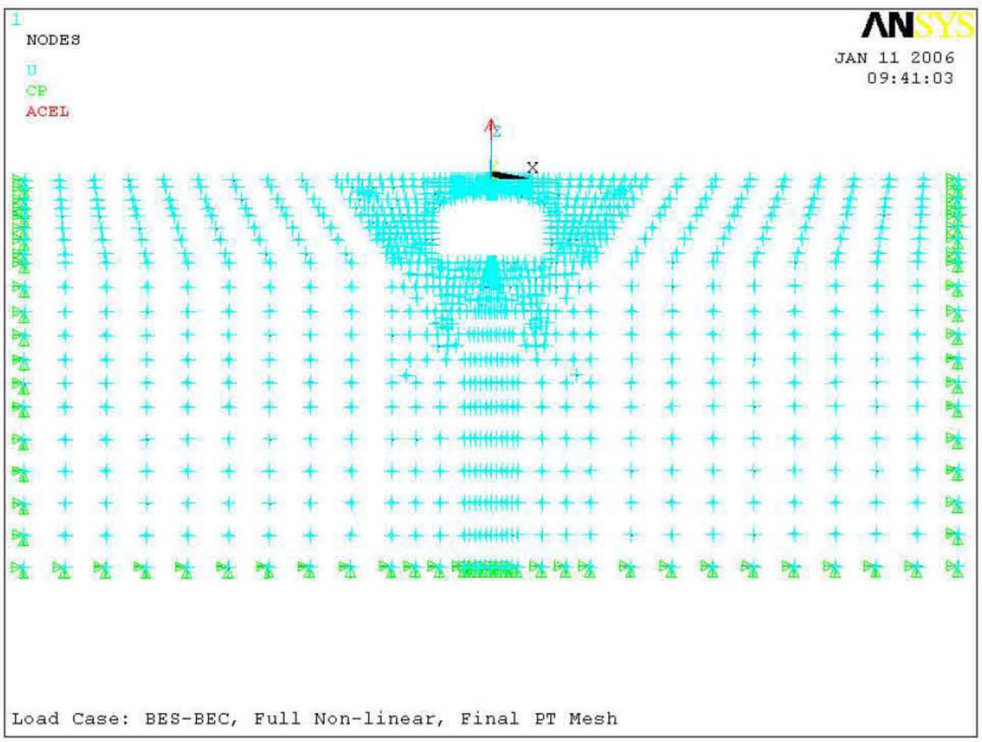

Figure 3-30. Boundary Conditions – Symmetry Plane

3.4.2 Tank Boundary Conditions

The tank model has all nodes on the symmetry plane fixed to the Y translation, X rotation and Z rotation (See Figure 3-31 and Figure 3-32). Couples have been used between some components to ensure compatible displacements occur. Where no common nodes exist between the concrete tank and secondary liner, couples are used to control the deformation of the secondary liner where it is in contact with the concrete tank. This ensures that the secondary liner does not "pass through" the concrete on the footing and on the walls (See Figure 3-33).

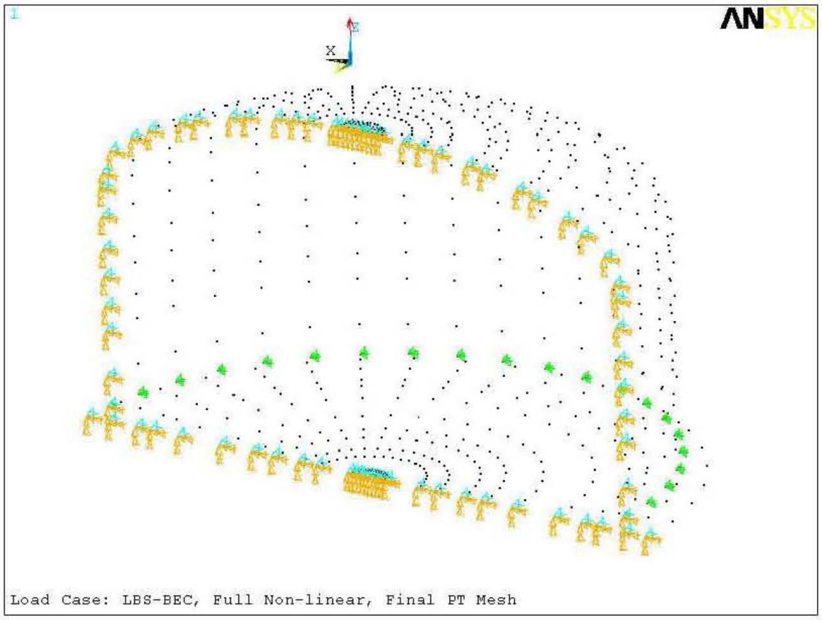

Figure 3-31. Boundary Conditions – Concrete Tank

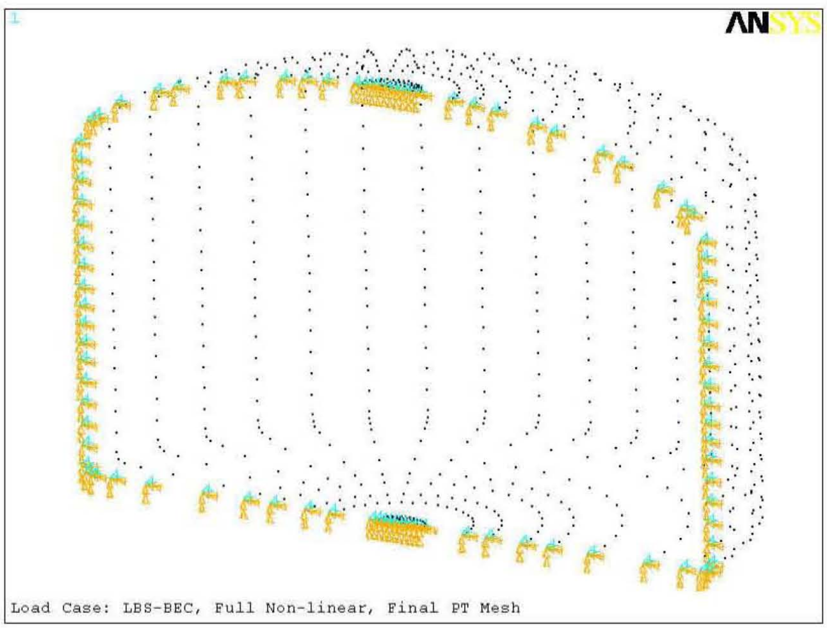

Figure 3-32. Boundary Conditions – Primary Tank

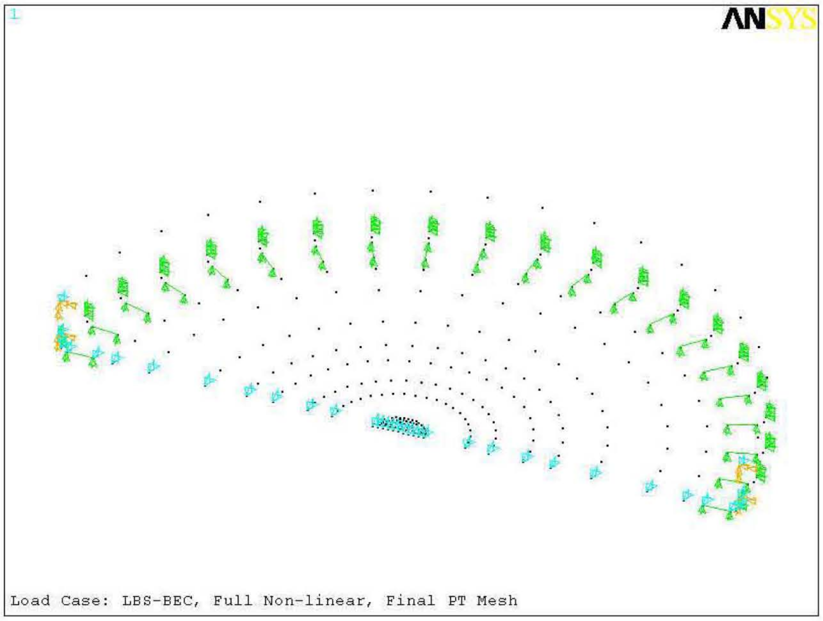

Figure 3-33. Boundary Conditions – Secondary Liner

3.5 Seismic Input

The seismic analysis of the DSTs requires appropriate acceleration time-history records representing the required seismic excitation. Time history records must be available for both the horizontal and vertical directions. Typically, the required seismic input is specified in terms of design spectra. If time-histories are required, such time histories are often synthesized numerically subject to certain requirements related to the proper representation of the design spectra (ASCE 1998, NUREG-0800). Generation of acceptable time-histories is not a trivial task. If time-histories exist that are appropriate for or can be modified appropriately to apply to the analysis of the DSTs, significant budget and schedule savings can be realized for the project. Accordingly, the time-history records used in this analysis of the DSTs were existing time-histories that were used on the Hanford Waste Treatment Project (WTP). The justification for the use of existing time-histories is presented below.

The Hanford Tank Farms Documented Safety Analysis or DSA (RPP-13033) designates the DSTs as Performance Category 2 (PC-2) structures. DOE-STD-1020-2002, Section 2, states that the ground motions for PC-2 shall be developed following IBC 2000, in which the surface response spectra are specified to be 2/3 of the Maximum Considered Earthquake (MCE) ground motions. The MCE ground motions are defined as the ground motions with a mean annual frequency of exceedance of 4×10^{-4} (2% probability of exceedance in 50 years). The MCE motions may be defined based on either the USGS National Hazard Mapping results, adjusted for the appropriate site classification, or from a site-specific Probabilistic Seismic Hazard Analysis (PSHA). If the MCE response spectrum is to be defined from a site-specific PSHA, it cannot be less that 80% of the spectrum defined from the USGS National Hazard Mapping results. The PC-2 ground motions used in the DST analysis are based on a site-specific PSHA. The detailed development of the PC-2 spectra for the DST Farms is documented in Geomatrix (2005).

Acceleration time-histories for two horizontal components and one vertical component of seismic motion were synthesized for the seismic design and evaluation of the Hanford Site WTP (BNFL 2000). The horizontal design spectrum for the WTP is anchored at 0.257*g* (peak ground acceleration (PGA), and the vertical design spectrum is anchored at 0.175*g* PGA. The time-histories generated to match the WTP design spectra were previously used by M&D in the preliminary soil-structure interaction analysis of the WTP high-level waste and pretreatment facilities, and were readily available (M&D 2001a and 2001b).

The Hanford Double-Shell Tank Farms horizontal design spectrum for 5% spectral damping is shown in Figure 3-34. Also shown in Figure 3-34 are the horizontal control motion spectra for the WTP project. All reference or control motions are defined at the soil surface. Similar plots for the vertical direction are shown in Figure 3-35.

The relationships between the design spectra and the control motion response spectra show that it is acceptable to use the acceleration time-histories from the WTP for the analysis of the DSTs.

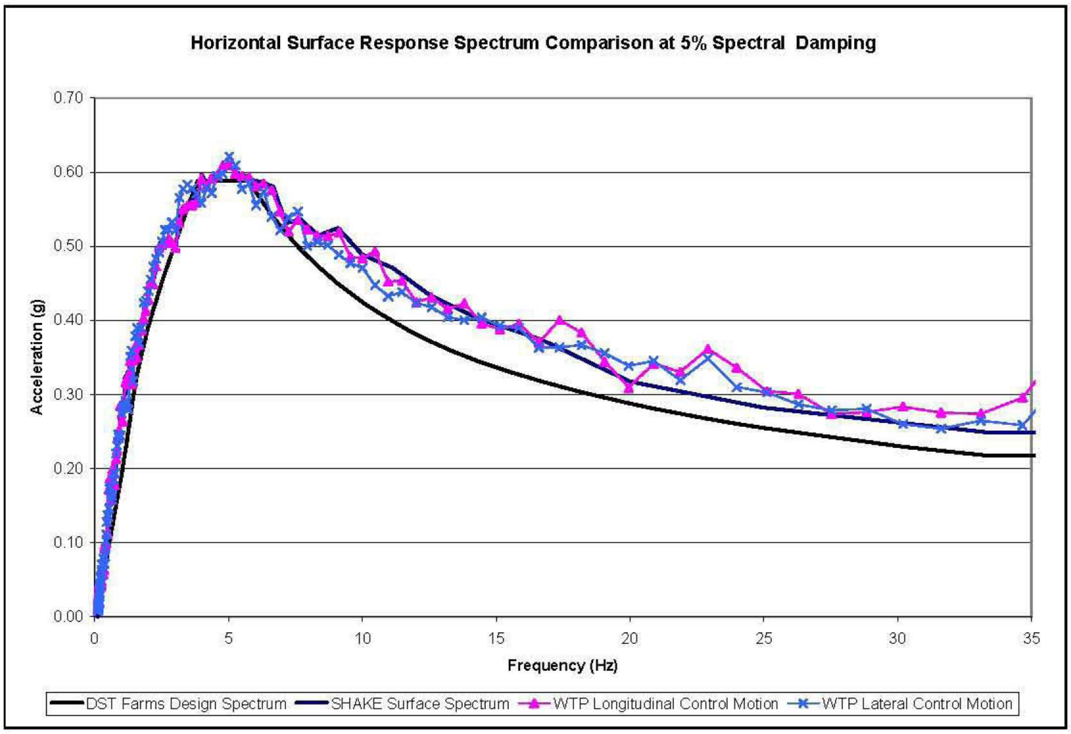

Figure 3-34. Comparison of Horizontal Surface Spectra at 5% Spectral Damping

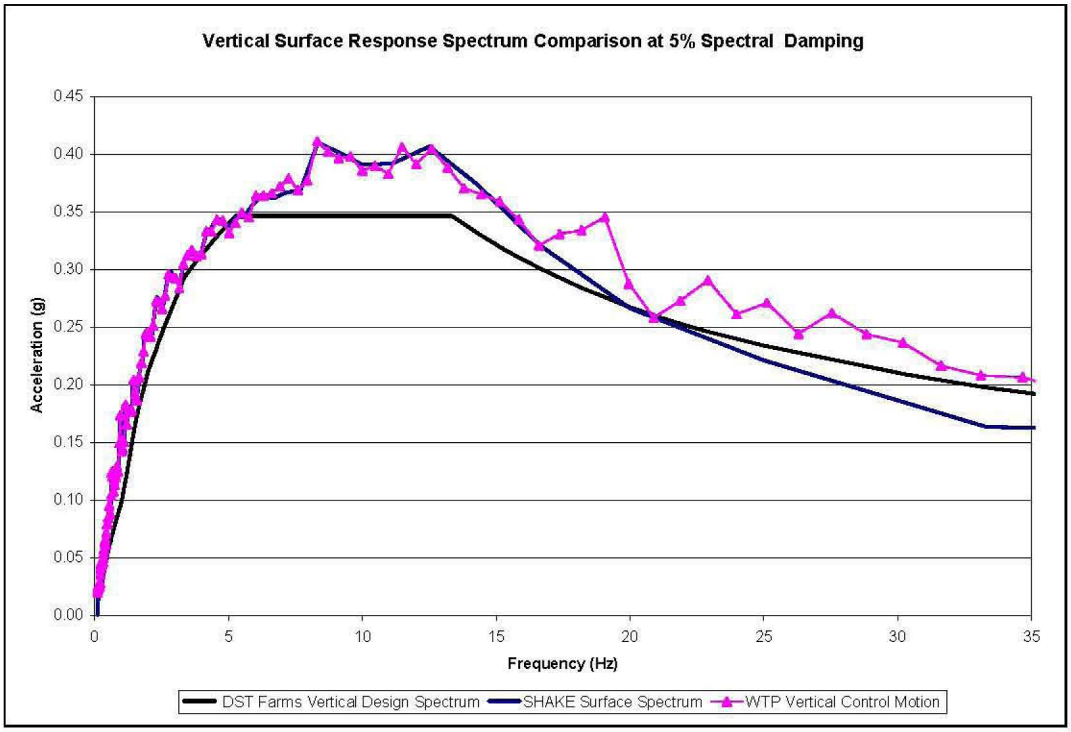

Figure 3-35. Comparison of Vertical Surface Spectra at 5% Spectral Damping

Acceleration and displacement time histories for horizontal and vertical input are shown in Figure 3-36 and Figure 3-37, respectively.

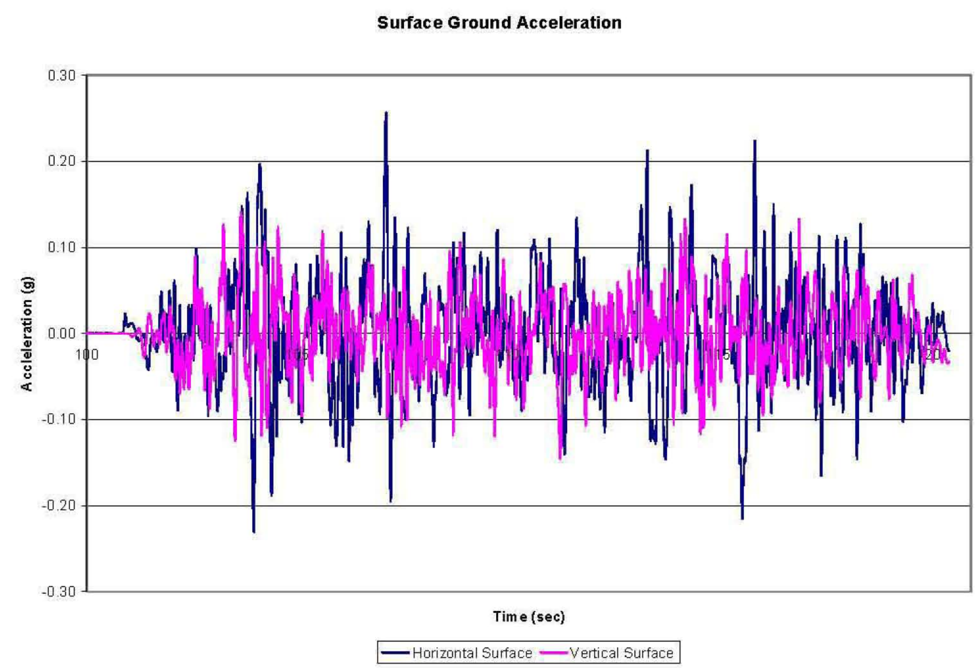

Figure 3-36. Horizontal and Vertical Surface Acceleration Time History

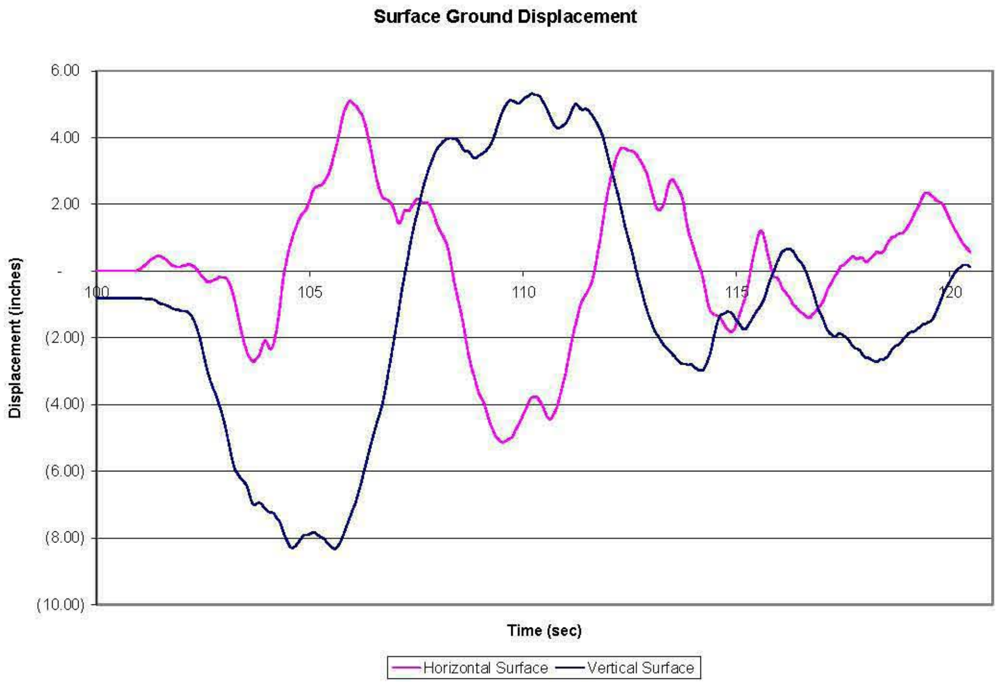

Figure 3-37. Horizontal and Vertical Surface Displacement Time History

3.6 Soil and Concrete Properties

Four combinations of soil and concrete properties have been considered in this analysis. These combinations are:

- Lower Bound Soil, Best-Estimate Concrete Properties
- Best-Estimate Soil, Best-Estimate Concrete Properties
- Upper Bound Soil, Best-Estimate Concrete Properties
- Best-Estimate Soil, Fully-Cracked Concrete Properties

The three variations in soil properties address the uncertainty as required by ASCE (1998). The Fully-Cracked Concrete case covers the additional uncertainty of expected concrete condition.

Each configuration is run as a full nonlinear seismic time history including gravity, and again separately as a gravity-only analysis. The difference between the two cases represents the seismic effects in the absence of gravity. Two input motions (horizontal and vertical) have been defined as acceleration time histories consisting of 2,048 time steps. Acceleration time histories were developed for each of the three soil conditions at the -266-ft level (Rinker et al. 2006a).

3.6.1 Acceptance Criteria for Response Spectra

The following acceptance or screening criteria were applied to the tank foundation-level response spectra generated by the ANSYS® column model:

1. The envelope of the Best-Estimate, Lower Bound, and Upper Bound response spectra at the tank foundation level (-57.6 ft) should be at least 60% of the surface control motion. This applies to both horizontal and vertical motion.

2. The envelope of the Best-Estimate, Lower Bound, and Upper Bound ANSYS® and Dytran response spectra at the tank foundation level (-57.6 ft) should be at least 90% of the SHAKE response spectrum.

3. The envelope of the Best-Estimate, Lower Bound, and Upper Bound ANSYS® and Dytran response spectra at the tank foundation level (-57 ft) should be greater than or equal to the SHAKE response spectrum over any ±15% bandwidth.

The above criteria should be met for both horizontal and vertical spectra. Additional criteria were evaluated for these input motions and response spectra. The additional criteria are discussed in Rinker et al. 2006a. The first condition is intended to minimize the dip that can occur in deconvolved response spectra at moderate depth at the frequency of the overlying soil column. Such a dip appears in the foundation level SHAKE spectrum shown in Figure 3-38 as well as in other plots.

The tests of the first criterion is shown graphically for both horizontal and vertical input as shown in Figure 3-38 and Figure 3-39, respectively. The results indicate that the first condition is not met at all frequencies. Modifications to ensure that the condition is met will be discussed in Section 3.6.2.

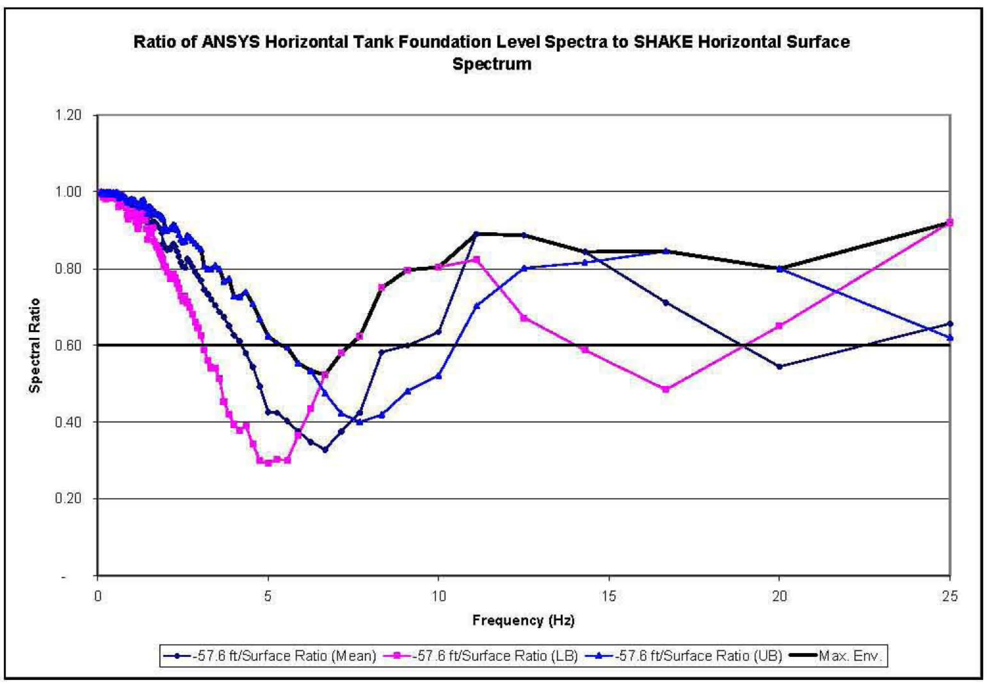

Figure 3-38. Ratio of the ANSYS® Tank Foundation Level Spectra to the SHAKE Surface Spectrum for Horizontal Excitation.

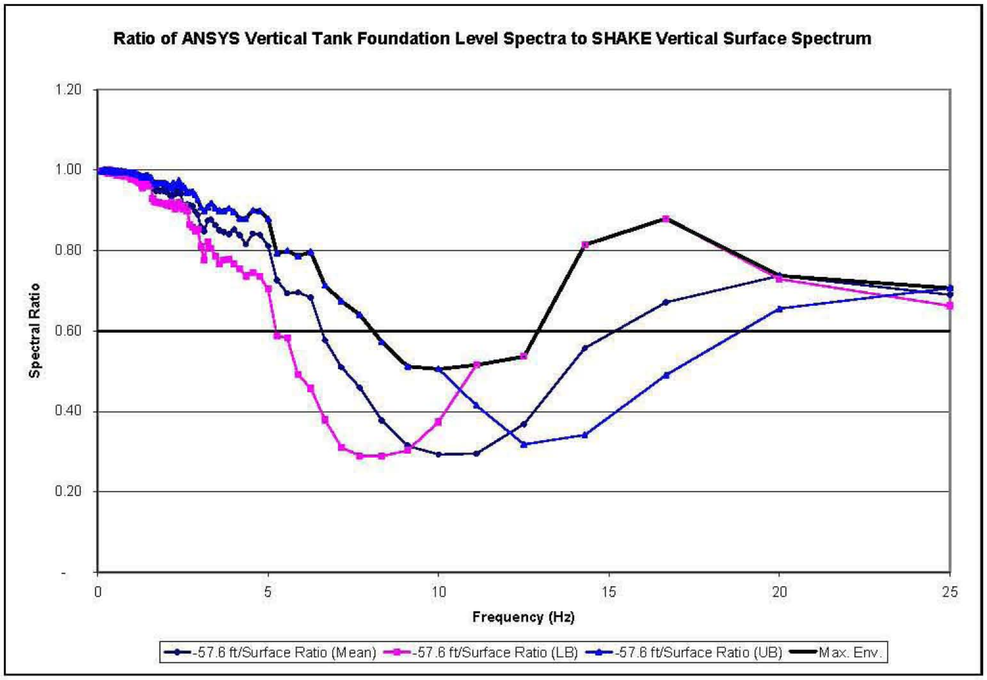

Figure 3-39. Envelope of the Ratio of the ANSYS® Tank Foundation-Level Spectra to the SHAKE Surface Spectrum for Vertical Excitation.

3.6.2 Modification to ANSYS Base Time Histories

Comparison of the ANSYS® soil column spectra at the tank foundation level to the SHAKE surface spectra for horizontal and vertical excitation (Figure 3-38 and Figure 3-39) showed that the tank foundation spectra do not meet the first criterion. The envelope of the Best-Estimate, Lower Bound, and Upper Bound response spectra at the tank foundation level (-57.6 ft) should be at least 60% of the surface control motion. This applies to both horizontal and vertical motion. To ensure that the envelope of the tank foundation level spectra is at least 60% of the SHAKE surface spectrum, the horizontal Lower and Upper Bound base time histories used as input to the ANSYS® soil column model were scaled up by factors of 1.175 and 1.12, respectively. The vertical Lower and Upper Bound base time histories were scaled up by factors of 1.12 and 1.19, respectively. Comparisons of the tank foundation-level spectra to the SHAKE surface spectra for the modified base time histories are shown in Figure 3-40 and Figure 3-41. Increasing the base time histories by the above factors results in the ratio of the tank foundation-level spectra to SHAKE surface spectra meeting the 60% criterion.

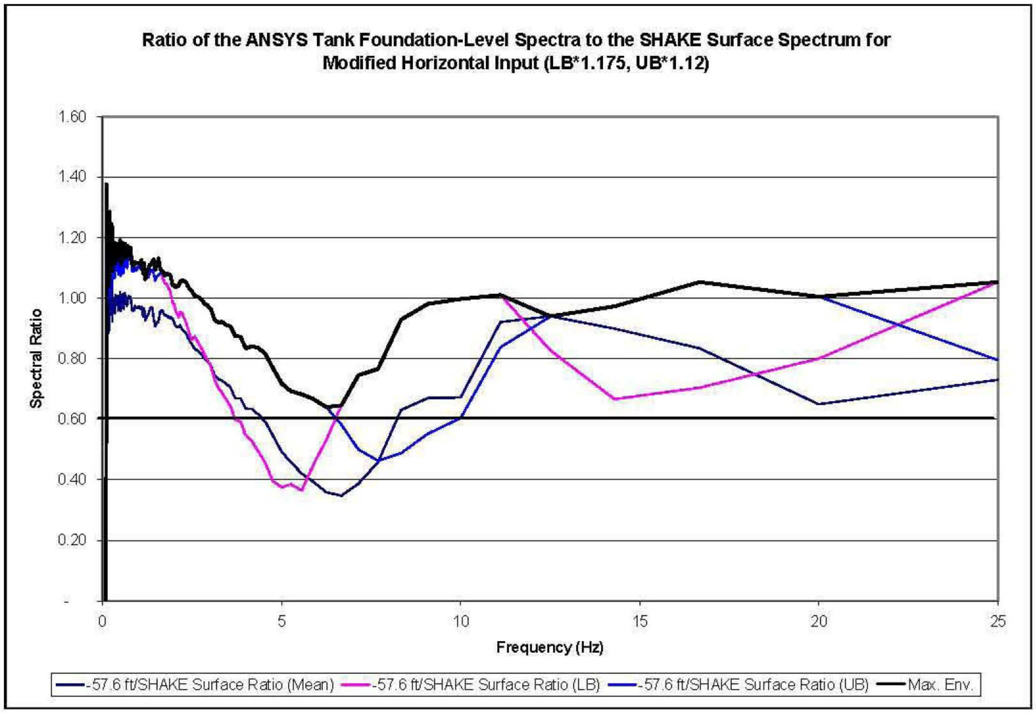

Figure 3-40. Ratio of the ANSYS® Tank Foundation Level Spectra to the SHAKE Surface Spectrum for Modified Horizontal Excitation

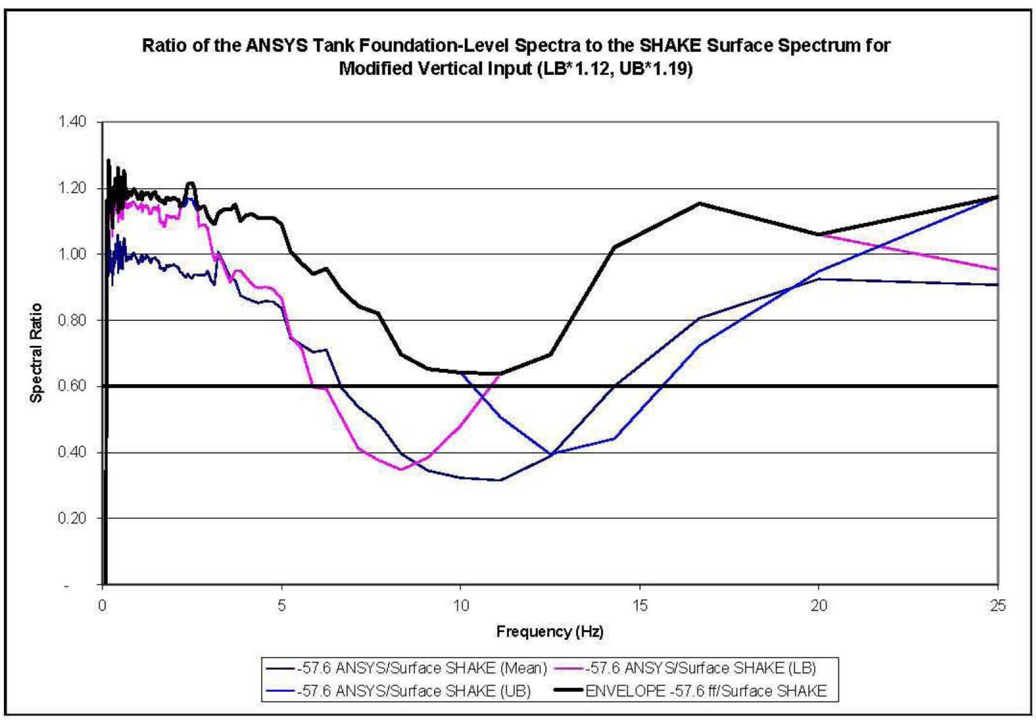

Figure 3-41. Envelope of the Ratio of the Tank Foundation Level Spectra to the Surface Spectra for Modified Vertical Excitation

3.6.3 ANSYS® Base Acceleration Time Histories

Individual time histories are applied for each different soil condition. Lower Bound, Best-Estimate, and Upper Bound soil horizontal and vertical acceleration time histories are shown in Figure 3-42, Figure 3-44, and Figure 3-46, respectively. Lower Bound, Best Estimate, and Upper Bound soil horizontal and vertical displacement time histories are shown in Figure 3-43, Figure 3-45, and Figure 3-47, respectively.

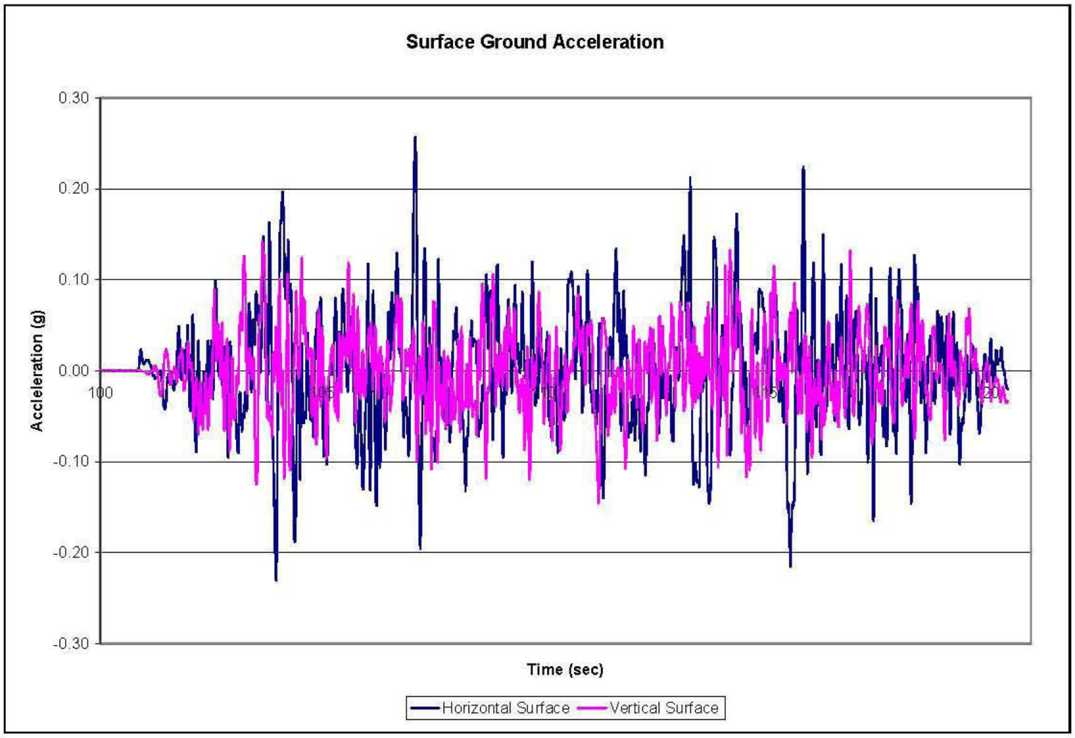

Figure 3-42. Horizontal and Vertical Base Acceleration Time History, -266 ft, Lower Bound Soil

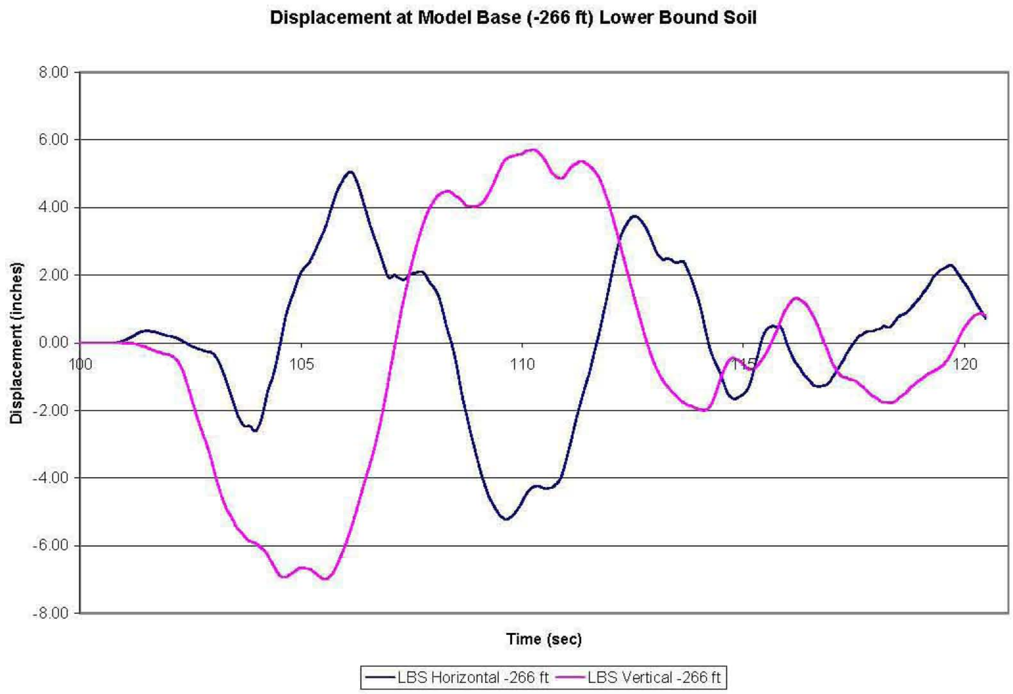

Figure 3-43. Horizontal and Vertical Base Displacement Time History, -266 ft, Lower Bound Soil

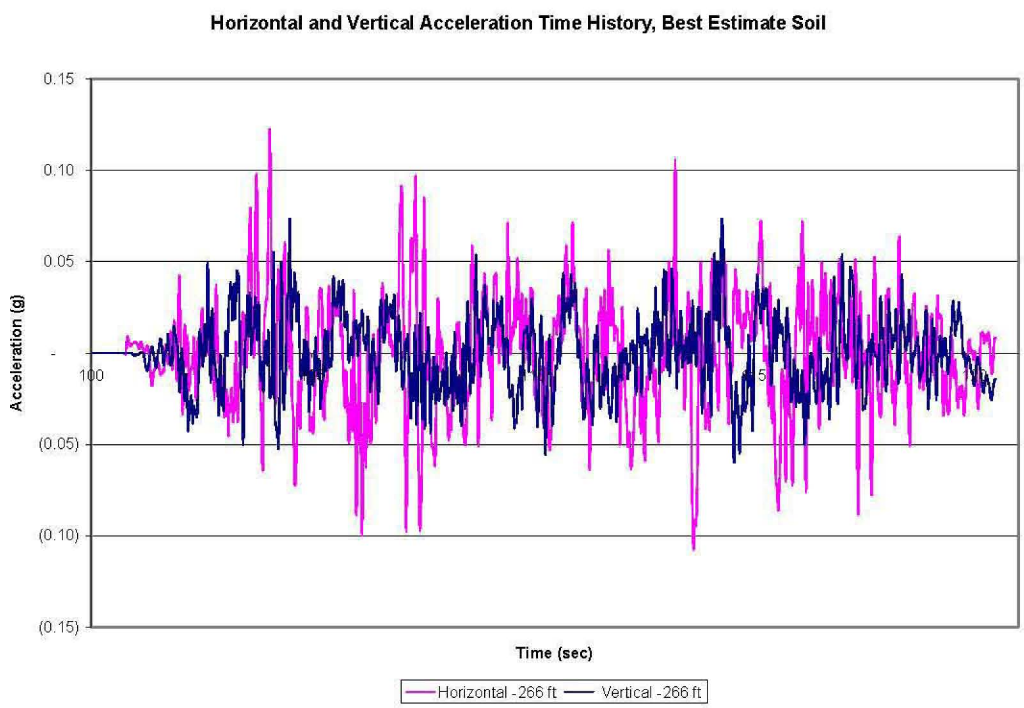

Figure 3-44. Horizontal and Vertical Base Acceleration Time History, -266 ft, Best Estimate Soil

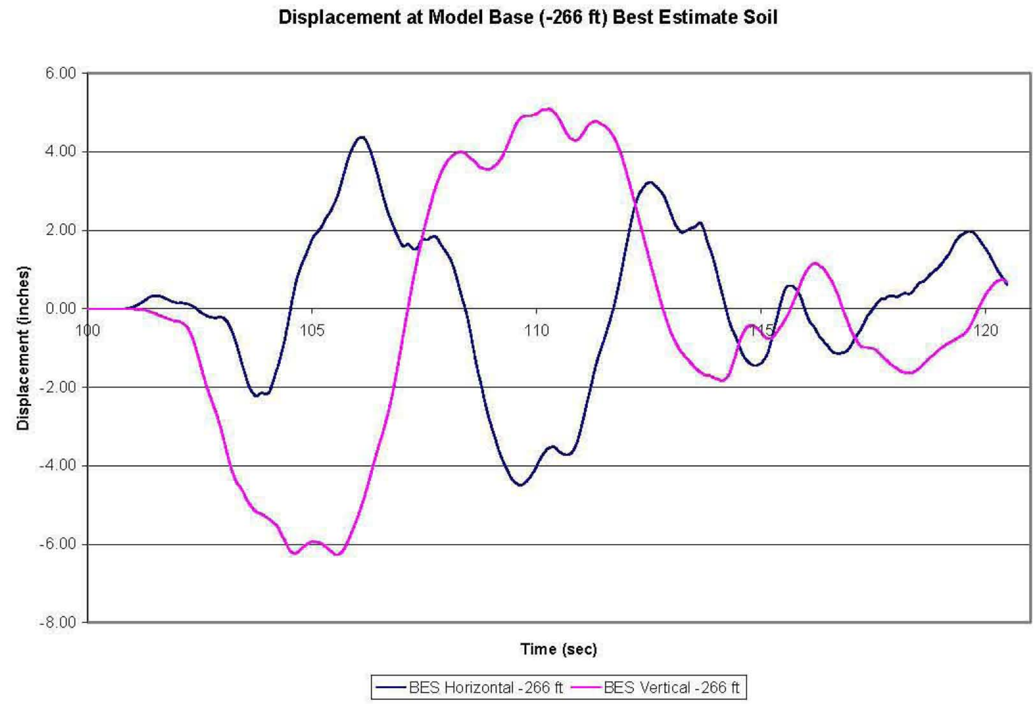

Figure 3-45. Horizontal and Vertical Base Displacement Time History, -266 ft, Best Estimate Soil

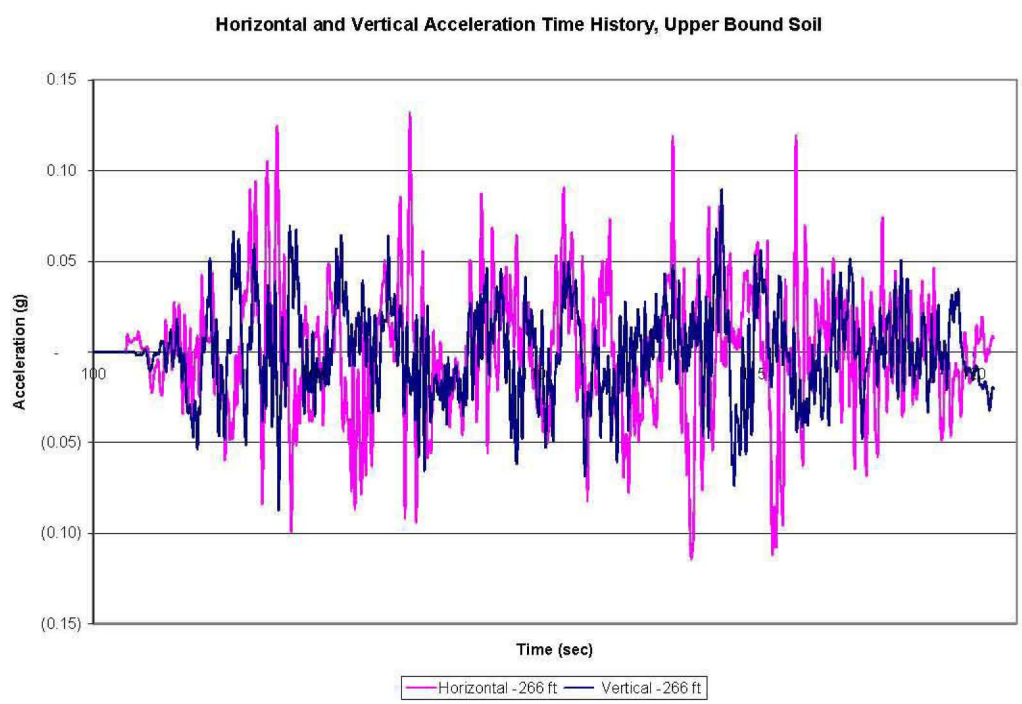

Figure 3-46. Horizontal and Vertical Base Acceleration Time History, -266 ft, Upper Bound Soil

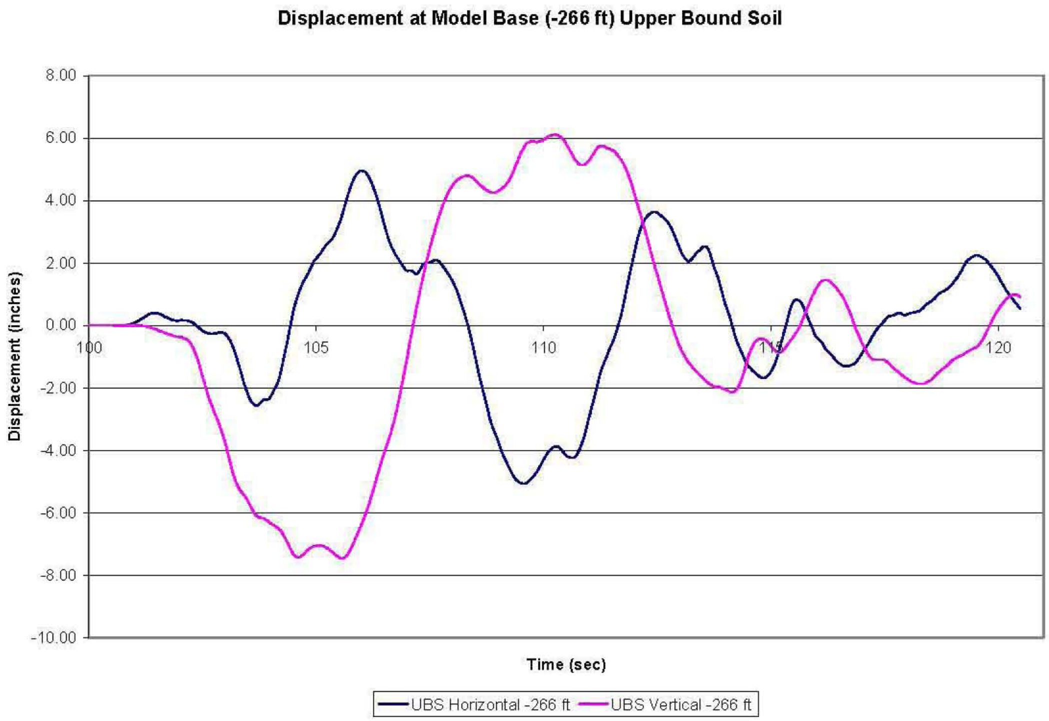

Figure 3-47. Horizontal and Vertical Base Displacement Time History, -266 ft, Upper Bound Soil

3.7 Model Excitation

An acceleration time history extracted from SHAKE at the -266 ft level is used for the excitation of the full model. A very large mass element is located at the bottom of the soil model (-266 ft) and a force is applied to that node. The force is the product of the point mass and the acceleration for that time step of the time history. The point mass used is greater than 100 times the mass of the full model.

4.0 Model Reconciliation

The finite element models used in the TOLA and seismic analyses are significantly different. Reviewing the figure and model description in Chapters 2 and 3 readily demonstrates the dissimilarities. The non-axisymmetric nature of the earthquake load requires the seismic model to encompass at least 180°. The acceleration time history used to represent the earthquake comprised 2,048 load steps to achieve the 20.48 seconds of the transient analysis. Minimizing the model size was important in achieving a reasonable solution run time on the computer. Consequently the element size is quite large in comparison to the TOLA model.

In contrast, the TOLA analysis has no inherent non-axisymmetric features. The 3D model was made necessary only by the desire to use SOLID65 concrete element in ANSYS®. A refined mesh was implemented to obtain better resolution of stress throughout the model, particularly in the knuckle region.

The disparity between models required a mapping procedure in order to combine the TOLA and seismic results. This section summarizes the mapping for the different evaluations.

- Table 4-1 shows the element correlation for the ACI evaluation.
- Table 4-2 shows the element correlation for the ASME primary tank evaluation
- Table 4.3 shows the element correlation for the ASME concrete-backed liner evaluation. The secondary liner in the seismic model extended only across the floor and up to the second element in the wall (see Figure 3-12). Consequently, seismic strain in the wall and haunch was taken from the concrete shell elements representing the wall. Strain in the dome was taken from the steel liner.
- Table 4-4 shows the correlation for the anchor bolts.

Concerns were raised by the reviewers regarding the mesh refinement in the lower knuckle of the primary tank. The TOLA model uses eight elements to represent the knuckle while the seismic model has two elements in this region. A mesh sensitivity study was conducted to evaluate the effect of element size on the stress results from the seismic model (see Appendix A). The study concluded that doubling the meridional and hoop stress components (or the stress intensity) in the knuckle elements from the coarser seismic model was more than adequate to account for the difference in resolution between a two-element and eight-element seismic model.

However, it should be noted that the maximum demand/capacity ratio for the primary tank appears in the general membrane stress intensity evaluation (e.g. Figure 6-24) outside the lower knuckle region. An example of the local primary + bending stress intensity evaluation is shown in Figure 4.1. The TOLA stress is plotted separate from the combined stress such that the increment due to the seismic load is apparent. It can be seen that even if the seismic contribution were to double in the 7/8 in. lower knuckle, there is still substantial margin. Therefore, the coarse mesh in the lower knuckle is not a concern.

Table 4-1. Element Correlation for ACI Evaluation

Seismic Element #	R (in.)	Z (in. up)	TOLA Section #
7	22.5		
57	67.6998		2
77	105.5598		3
97	136.812		4
117	182.154		6
137	225.252		8
157	272.862		9
177	321.114		11
197	364.65		13
217	411.198		17
237	449.298		20
257	478.398	431.244	21
277	487.95	398.598	24
297	489	362.55	26
317	489	312	30
337	489	262.746	33
357	489	215.646	35
377	489	170.148	38
397	489	111.744	41
417	489	48.996	43
437	489	12	46
457	510		48
477	463.5		52
497	424.002		54
517	384		55
537	317.85		57
557	248.1		59
577	199.248		60
597	154.95		61
617	112.8		62
637	65.85		63

Table 4-2. Element Correlation for Primary Tank Evaluation

Seismic Element #		R (in.)	Z (in. up)	TOLA Element #
762		67.3014		15276
782		104.9316		15264
802		135.9828		15324
822		181.008		15303
842		223.788		15258
862		270.978		15247
882		318.738		15227
902		361.632		15211
922		406.242		15185
942		426.948		15197
962		440.814		15178
982	wall	450	410.742	15167
1002		450	386.496	15161
1022		450	359.496	15154
1042		450	331.992	15147
1062		450	304.992	15140
1082		450	277.992	15134
1102		450	250.992	15127
1122		450	225.642	15120
1142		450	202.296	15115
1162		450	179.298	15109
1182		450	156.348	15103
1202		450	131.448	15097
1222		450	104.496	15090
1242		450	77.496	15083
1262		450	50.496	15076
1282	wall	450	24.498	15070
1302	knuckle	448.242	7.752	15064
1322	knuckle	442.242	1.752	15061
1342	floor	424.002	0	15054
1362		384		15042
1382		317.85		15021
1402		248.1		14999

Table 4-3. Element Correlation for Concrete-Backed Liner Evaluation

Seismic Element #		R (in.)	Z (in. up)	TOLA Element #
762	dome	68.02		15276
782		105.91		15264
802		136.01		15324
822		180.6		15303
842		224.26		15258
862		272.27		15247
882		318.015		15227
902		362.525		15211
922		405.475		15185
237		448.92		15804
257		471.63		15814
277		479.165		15798
297	wall	480	353.5	15912
317		480	302.5	15897
337		480	254.5	15877
357		480	206.5	15866
377		480	161.5	15851
397		480	107.5	15837
2062		480	41.5	15819
2052	wall	480	8.4125	15953
2042	knuckle	478.99	7.752	15785
2032	knuckle	472.555	1.752	15788
477	floor	448.5	0	15795
497		416.665		15654
517		378.355		15666
537		311.305		15687
557		244.255		15708
577		196.36		15723
597		151.66		15737
617		110.155		15750
637		65.4535		15764

Table 4-4. Element Correlation for Anchor Bolt Evaluation

Seismic J-Bolt	Seismic Radius	TOLA Radius	TOLA scale factor
Radius 4	120.0	107.5	4.465
Radius 5	152.0	167.6	2.864
Radius 6	210.1	208.5	2.302
Radius 7	237.5	243.3	1.973
Radius 8	304.4	300.5	1.597
Radius 9	333.1	325.2	1.476
Radius 10	390.2	391.7	1.225
Radius 11	422.3	413.4	1.161

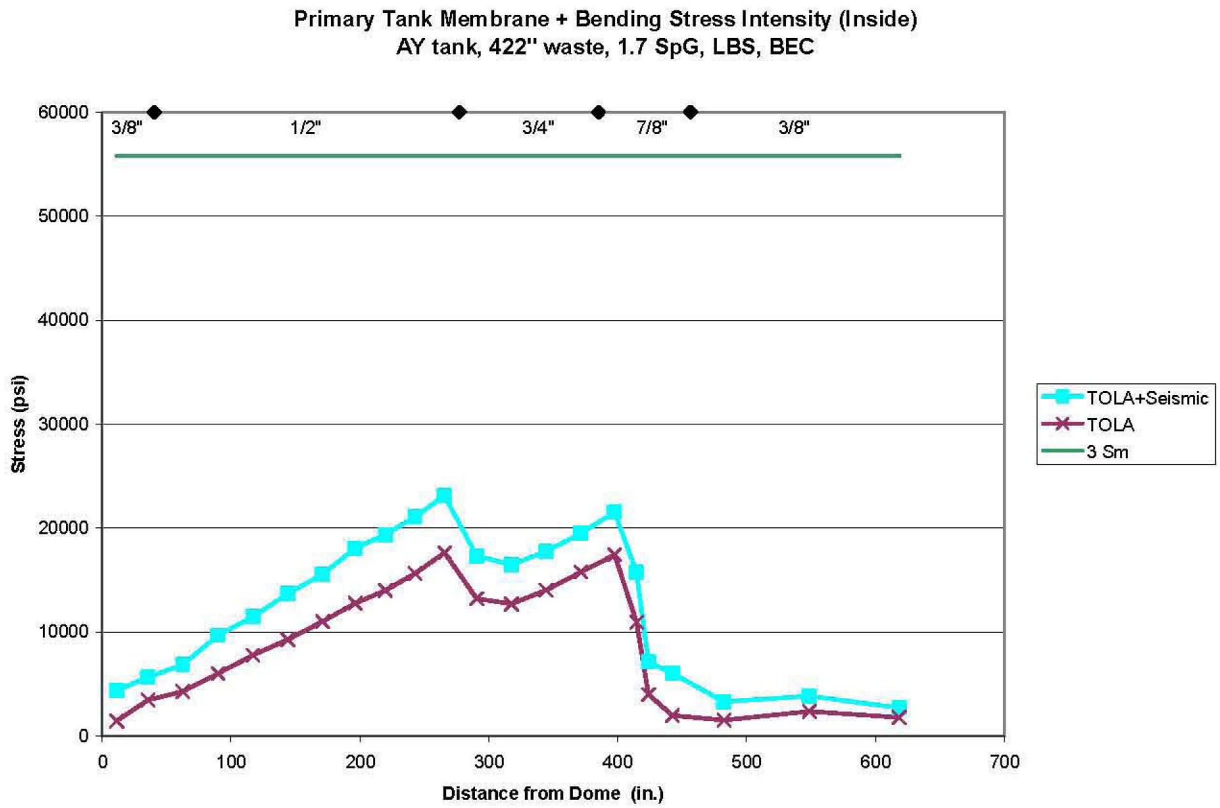

Figure 4-1. Seismic Contribution to the Membrane + Bending Stress Intensity Evaluation

5.0 Structural Acceptance Criteria

5.1 Introduction

This chapter describes the code-based acceptance criteria that are used to evaluate the bounding double-shell tank for the Combined Thermal and Operating Loads (TOLA) and Seismic Analysis. A complete description of the evaluation criteria is found in the Thermal and Operating Loads Analysis report (Rinker et al. 2004).

Day et al. (1995) provides a definitive summary of code-based structural acceptance criteria that govern the current and future uses of the Hanford DSTs. The document covers the primary objectives of any reevaluation of the existing waste storage tanks for continued operation or remediation, namely: 1) to show that the tank structures remain within code-based limits for the original design-based loads, 2) to evaluate if the actual service conditions or changes in requirements will exceed the design conditions, or 3) to evaluate current operating loads and future remediation activity loads.

The structural acceptance criteria document by Day et al. (1995) describes the tank designs, loads that must be sustained, potential failure modes, and the recommended approaches to protect against such failure. The application of code-based evaluation methods is discussed in detail. Alternate methods to the code-based approach are recommended to account for localized overstressing, load redistribution, and reduction in section capacities due to material degradation. Code reconciliation issues and material degradation under aging conditions also are addressed.

The purpose of this chapter is to identify a) the design and construction standards that were used for the DST designs, b) the allowable stresses for the steels and the minimum specified strengths of the concrete that were specified in the design, and c) the analysis methods that will be used to evaluate the structural adequacy of the bounding tank design. Tank 241-AY was shown in the TOLA report (Rinker et al. 2004) to be the bounding tank design based on geometrical considerations, the specified material strengths, and section capacities. Therefore, items a) and b) concentrate on the specifications for the 241-AY tank design. Because Day et al. (1995) specifically identifies the recommended code-based methods for tank evaluation, they are not reproduced in this document.

5.2 Design and Construction Specifications for Tank 241-AY

The design and construction specifications list the standards that were used in the design and construction of the 241-AY tank farm. Specifications that are pertinent to the steel and concrete structure include:

- HWS-7789, Primary and Secondary Steel Tanks
- HWS-7790, Excavation and Tank Foundations
- HWS-7791, Side Walls and Dome.

HWS-7789 documents that the 241-AY tanks were designed, fabricated, and inspected to the intent of the 1965 ASME Boiler and Pressure Vessel Code. (Note: Although the ASME code standards were followed, the tanks were not registered as ASME vessels due to the non-standard nature of their design, use, and contents.) The steel plate used to construct the primary and secondary liners is specified as "ASTM A515-65 carbon steel plates of intermediate tensile strength for fusion-welded boilers and other pressure vessels for intermediate and high temperature service" (ASTM 1965). Abatt (1996) lists the ASME S_m allowables that were specified for the pressure vessel steels for each of the DST designs (see Table 5.1).

HWS-7790 and HWS-7791 document that the 241-AY tanks were constructed to the 1963 ACI 318 building code requirements for reinforced concrete (ACI 1963). In addition, structural concrete for the foundation, tank walls, and miscellaneous structures was required to have a minimum allowable compressive strength of 3000 psi at 28 days. The other tanks specify concrete of higher strength (4,500 and 5,000 psi).

5.3 Applicable Codes

5.3.1 Design Codes of Record for the DSTs

Abatt (1996) identifies SDC 4.1, *Standard Arch-Civil Design Criteria - Design Loads for Facilities*, as the standard for the design of tanks at the Hanford Site. This standard has been in existence since the original document was published in April 1957, and it has been revised since then to comply with current DOE orders. More recently, SDC 4.1 was superseded by HNF-PRO-097, *Engineering Design and Evaluation (Natural Phenomena Hazard)* (HNF-PRO-097 2002). However, HNF-PRO-097 (2002) is a more general standard in use by the Project Hanford Management Contractor and a similar standard, TFC-ENG-STD-06, *Design Loads for Tank Farm Facilities* (Mackey 2004) is used by the Tank Farm Contractor.

5.3.2 Steel Design Codes of Record

Abatt (1996) summarized the codes of record that were used during the design of the various DST farms. The codes pertaining to the steel liner and tank components are listed in Table 5-1.

Table 5-1. Summary of the S_m Allowables that were Specified for Each of the DST Designs (Abatt 1996)

Tank Farm 241-	Construction Years	Max. Temp, °F	Primary Tank Design Code	ASTM Plate Spec.	Minimum Specification	Temperature, °F					
						100	200	250	300	350	400
AY	1968–1970	350	ASME Section VIII, Div. 2 (1965)	A515	S_y (ksi) = 32	32	29.2	28.8	28.3	27.9	27.4
				Gr. 60	S_{ult} (ksi) = 60	60	60	60	60	60	60
					S_m (ksi)	20	19.5	19.2	18.9	18.6	18.3
AZ	1971 &1977	350	ASME Section III, (1968)	A515	S_y (ksi) = 32	32	29.2	28.8	28.3	27.9	27.4
				Gr. 60	S_{ult} (ksi) = 60	60	60	60	60	60	60
					S_m (ksi)	20	19.5	19.2	18.9	18.6	18.3
SY	1974–1976	250	ASME Section III, Div. 1 (1971 & 1973 addenda)	A516	S_y (ksi) = 35	35	31.9	31.5	31.0	30.5	30.0
				Gr. 65	S_{ult}(ksi) = 65	65	65	65	65	65	65
					S_m (ksi)	21.7	21.3	21.0	20.7	20.3	20.0
AW	1978–1980	350	ASME Section VIII, Div. 2 (1974 & summer 1975 addenda)	A537	S_y (ksi) = 50	50	44.1	42.3	40.5	39.0	37.5
				Class 1	S_{ult} (ksi) = 70	70	70	70	70	70	70
					S_m (ksi)	23.3	23.3	23.1	22.9	22.9	22.9
AN	1980–1981	350	ASME Section VIII, Div. 2 (1974 & 1976 addenda)	A537	S_y (ksi) = 50	50	44.1	42.3	40.5	39.0	37.5
				Class 1	S_{ult} (ksi) = 70	70	70	70	70	70	70
					S_m (ksi)	23.3	23.3	23.1	22.9	22.9	22.9
AP	1983–1986	210	ASME Section VIII, Div. 2 (1980 & winter 1981 addenda)	A537	S_y (ksi) = 50	50	44.1	42.3	40.5	39.0	37.5
				Class 1	S_{ult} (ksi) = 70	70	70	70	70	70	70
					S_m (ksi)	23.3	23.3	23.1	22.9	22.9	22.9

5.3.3 Concrete Design Codes of Record

Abatt (1996) also summarized the codes of record that pertain to the reinforced concrete structure of the tanks. These codes are listed in Table 5-2. Table 5-2 shows that the 241-AY tanks were designed to the standards of the 1963 revision of ACI 318.

Table 5-2. Summary of Hanford Double-Shell Tank Structural Concrete Design Basis (Abatt 1996)

Tank Farm 241-	**Const. Years**	**Design Code / Specified 28-day Compressive Strength (10^3 lbf/in.^{2}) Dome & Haunch**	**Wall**	**Basemat Foundation**	**Insulation Concrete[(a)]**	**Reinforcing Steel Rebar (ASTM)**	**Cross-Ties (ASTM)**	**Welds**
AY	1968–70	ACI 318 (1963)				A15-65 FDN Gr. 40 A432-66 Shell Gr .60	A432-66 Gr. 60	NA
		3 (Type III)	3 (Type II)	3	0.200			
AZ	1971 & 77	ACI 318 (1963)				A615-68 Gr .60	A615-72 Gr. 60	NA
		3	3	3 (Type V)	0.200			
SY	1974–76	ACI 318 (1971)				A615-72 Gr. 60	A615-72 Gr. 40	AWS D12.1
		4.5 (Type III)	4.5 (Type II)	3(4.5)[(b)] (Type V)	0.130			
AW	1978–80	ACI 318 (1971)				A615-76a Gr. 60	A615-76a Gr. 40	AWS D12.1 HPS-220-W
		5 (Type III)	5 (Type II)	4.5 (Type II)	0.130			
AN	1980–81	ACI 318 (1971)				A615-75 Gr. 60	A615-75 Gr. 40	AWS D12.1 HPS-220-W
		5 (4.5)[(c)] (Type III)	5 (4.5)[(c)] (Type II)	4.5 (Type II)	0.130			
AP	1983–86	ACI 349 (1976)				A615-81a Gr. 60	A615-81a Gr. 60	AWS D1.4
		5	5	4.5 (Type II)	0.130			

(a) The insulating concrete material is a cast-in-place lightweight refractory concrete material.
(b) From H-2-37704
(c) From H-2-71907
Type II = Low-alkali Portland cement – used where moderate exposure to sulfate attack is anticipated. Type II cement is in common use in western United States. Type II cement gains strength a little more slowly than general-purpose Type I cement but ultimately attains strength of Type I cement.
Type III = High-early-strength cement – develops in 7 days the same strength that is achieved at 28 days for concrete made from Types I or II cement, but may not achieve the long-term strength of Types I or II.
Type V = Sulfate-resisting cement – strength characteristics are equivalent to Type II.
ACI = American Concrete Institute
ASTM = American Society of Testing and Materials
AWS = American Welding Society
FDN = Foundation (basemat)
HPS = Hanford Plant Standard
NA = not applicable

5.3.4 Contemporary Codes for Structural Evaluation of the DSTs

Day et al. (1995) lists the following DOE orders as applicable to the analysis and structural qualification of the existing DSTs for continued operation:

- DOE Order 6430.1A, *General Design Criteria* (DOE 1989)
- DOE Order 5480.28, *Natural Phenomena Hazard Mitigation* (DOE 1993)

Note that DOE Order 420.1, *Facility Safety*, Section 4.4, Natural Phenomena Hazard Mitigation (DOE 2000), superseded DOE Order 5480.28. In addition, DOE Order 6430.1A has been cancelled.

Day et al. (1995) further states that the analysis and structural qualification of the existing DSTs for continued operation must be performed using the following codes and standards as guidance:

- BNL 52527, *Guidelines for Development of Structural Integrity, Programs for DOE High-Level Waste Storage Tanks* (Bandyopadhyay 1997)
- U.S. DOE Report UCRL 15910, *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards* (UCRL 1990) (superseded by DOE-STD-1020-2002)
- ASCE Standard 4-86, *Seismic Analysis of Safety Related Nuclear Structures and Commentary on Standard for Seismic Analysis of Safety Related Nuclear Structures* (ASCE 1986)
- Hanford Plant Standards, HPS-SDC-4.1, Rev. 12, *Standard Arch-Civil Design Criteria, Design Loads for Facilities* (SDC-4.1 1993) (superseded by TFC-ENG-STD-06)
- TFC-ENG-STD-06, *Design Loads for Tank Farm Facilities*, CH2M Hill Hanford Group, Inc. (Mackey 2004)
- BNL 52361, *Seismic Design and Evaluation Guidelines for the Department of Energy High Level Waste Tanks and Appurtenances* (Bandyopadhyay et al. 1995)

Specific guidance is given by Day et al. (1995) on the code analysis methods to be used in evaluating the major components of the tank, namely:

Primary Tank: The primary tank shall be evaluated against the requirements of the ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NC, Article NC-3200 (ASME 1992a). (Note: The design by analysis methods of Section III, Article XIII-1000, "Design Based on Stress Analysis," are equivalent to the analysis requirements of Section VIII, Division 2 (ASME 1992b). The primary difference between Section III [nuclear vessels and piping] and Section VIII [non-nuclear vessels and piping] involves the increased level of material qualification and fabrication inspection required by Section III.

Secondary Concrete Structure: The secondary concrete structure shall be evaluated against the requirements of ACI 349-90, Code Requirements for Nuclear Safety Related Concrete Structures (ACI 1992). While the AY tanks were designed to ACI-318, ACI-349 provides essentially the same technical design provisions. Mackey (2004a) notes that using ACI-349 as the evaluation criteria would not change the calculation results.

Secondary Tank Liner: The secondary tank liner shall be evaluated using the requirements of the ASME Boiler and Pressure Vessel Code, Section III, Division 2, Subsection CC (ASME 1992c). Those portions of the liner which are not backed by concrete shall be evaluated to the requirements of the ASME Boiler and Pressure Vessel Code, Section III, Division 2, Subsection NC (ASME 1992a). (Note: The evaluation methods of Section III, Division 2, Subsection CC are recommended because the steel-lined, reinforced concrete tanks are similar in construction to concrete nuclear containment vessels, which Subsection CC covers. Section VIII does not provide specific guidance on the evaluation of steel liners backed by concrete. Therefore, the analysis methodology recommended in Section III will be adopted [as recommended by Day et al. (1995)], even though the tanks where not strictly designed, constructed, and inspected to Section III standards.)

Insulating Concrete Pad: The insulating concrete pad shall be evaluated against the bearing stress requirements of ACI 349-90, *Code Requirements for Nuclear Safety Related Concrete Structures* (ACI 1992).

Primary Tank Dome and Secondary Liner Anchorage System: The anchorage systems for that portion of the tank steel which is backed by concrete shall meet the requirements of the ASME Boiler and Pressure Vessel Code, Section III, Division 2, Subsection CC (ASME 1992c).

Abatt (1996) presents a compilation of the ASME allowable stresses and the load factor combinations that were used in performing "design by analysis" evaluations of the DST primary tanks. Later sections of Day et al. (1995) give detailed guidance on how to apply these codes to analyze the tanks. Section 2 of Day et al. (1995) provides guidance on defining the tank loads (normal, abnormal, and extreme loads) for consideration in the analysis.

Potential failure modes are identified and discussed in detail in Section 3 of Day et al. (1995) for specific tank components as summarized here in Table 5-3.

Section 4 of Day et al. (1995) presents detailed discussion of the ASME code methods for evaluating the above failure modes in the primary tanks, secondary liner, and the anchor bolts. Section 4 also presents a similarly detailed discussion of the ACI code methods for evaluating the reinforced concrete tank walls and dome. This includes examples of the load combinations and load scaling factors required by the code.

Section 5 of Day et al. (1995) gives guidance on what to consider in reconciling differences in the current versions of the ASME and ACI codes when reanalyzing the DSTs. The "design by analysis" methods recommended by the ASME code have not changed in their application since the design of the 241-AY tanks. Therefore, the primary and secondary tank steels will be evaluated to the current methods using the S_m allowables and stress intensity classifications listed in Tables 5-1 and 5-4.

Table 5-3. Summary Table of the Local and Global Significance of Failure of the Various DST Components (Day et al. 1995)

Failure Mode	Steel Tank or Liner	Steel Reinforcement	Concrete	Soil
Buckling	L→L		G	
Collapse			G	
Fatigue	L→L	L→G	L→G	
Fracture	L→L			
Bond-Slip		L→G		
Plastic Failure	L→L	L→G	L→G	
Bearing Failure			L→L	L→L

L→L Local failure that could lead to leakage.
L→G Local failure that could lead to a global instability failure.
G Global instability failure.

Table 5-4. Stress Intensity Classification (Abatt 1996)

Vessel Component	Location	Origin of Stress	Type of Stress	Classification
Cylindrical or Spherical Shell	Shell plate remote from discontinuity	Internal pressure	General membrane gradient through plate thickness	P_m Q
		Axial thermal gradient	Membrane bending	Q Q
	Junction with head or flange	Internal pressure	Membrane bending	P_L Q
Any Shell or Head	Any section across entire vessel	External load or moment, or internal pressure	General membrane averaged across full section	P_m
		External load or moment	Bending across full section	P_m
	Near nozzle or other openings	External load or moment, or internal pressure	Local membrane bending	P_L Q
	Any location	Temperature difference between shell and head	Membrane bending	Q Q
Dished Head or Conical Head	Crown	Internal pressure	Membrane bending	P_m P_L
	Knuckle or injection to shell	Internal pressure	Membrane bending	P_L [(a)] Q

P_m Primary membrane
P_L Local membrane
Q Secondary
(a) Consideration shall also be given to the possibility of wrinkling and excessive deformation in vessels with large diameter-to-thickness ratio.

6.0 Analysis Results

6.1 ACI Structural Concrete Evaluation

The Structural Acceptance Criteria document, WHC-SD-WM-DGS-003 (Day et al. 1995) specifies that the reinforced concrete structure of the tanks shall be evaluated to the standards of ACI 349-90, Section 9.2. The requirements of the IBC are satisfied by virtue of meeting the standards of ACI-349. Chapter 19 of the IBC states that structural concrete shall be designed in accordance with the requirements of ACI-318. The commentary on ACI-349 describes the additional conservatisms for nuclear structures that exceed those in ACI-318. Accordingly, a structure that is shown to conform to ACI-349 satisfies the IBC.

The load factors to be applied in the DST analyses are a subset of the possible combinations specified in ACI 349-90, that subset being defined by and, further, reduced by the definition of the current work scope. Chapter 7 of the TOLA report (Rinker et al. 2004) indicates that load combinations 1, 4, and 9 are relevant for this study. The seismic loads are considered in load combination 4.

As noted previously, the seismic model does not contain as many elements as the TOLA model. Accordingly, the ACI evaluation of combined TOLA + seismic loads was conducted at 30 locations in the secondary concrete tank rather than the 63 locations recorded in the TOLA report. Figures 6-1 through 6-3 show the locations of these 30 sections.

The peak loads and moments from the seismic analysis were combined with the loads and moments from each load step of the thermal cycle in such a way as to maximize the demand/capacity ratio. In other words, the direction of the seismic loads and moments was ignored and the results were summed so as to give the worst possible combination of force and moments for that section. The peak seismic loads and moments were extracted from the seismic time history results without regard to azimuthal location in the tank or time during the seismic event. This simplified the combination of seismic and TOLA demands while maintaining a conservative position.

Load combination 1 ($U = 1.4(D + F) + 1.7(L + H)$) does not contain seismic loads. Accordingly, the results for this load combination were documented in the TOLA report (Rinker et al. 2004). The Upper Bound Soil – Best Estimate Concrete model had not been run at the time of the TOLA report, consequently those results are documented here in Section 6.1.2.

Load combination 4 ($U = D + F + L + H + T_o + E_{ss}$) requires a load factor of 1.0 on the dead, live, thermal and seismic loads. These results are presented for each of the four soil – concrete combinations. The seismic analysis generates non-axisymmetric loads which requires evaluation of the in-plane shear forces. The method of ACI 349-90, Section 11.10 was applied to the in-plane shear force.

Load combination 9 ($U = 1.05(D + F) + 1.3(L + H) + 1.05T_o$) does not contain seismic loads and was documented in the TOLA report. However, as noted above for load combination 1, the results for the Upper Bound Soil – Best Estimate Concrete analysis are reported here in Section 6.1.2.

6.1.1 Best Estimate Soil – Best Estimate Concrete

Figures 6-4 through 6-7 show the demand/capacity ratios for load combination 4 of the Best Estimate Soil – Best Estimate Concrete (BES-BEC) material combination. The demand/capacity ratios are all less than 1.0 in the meridional, circumferential and shear directions.

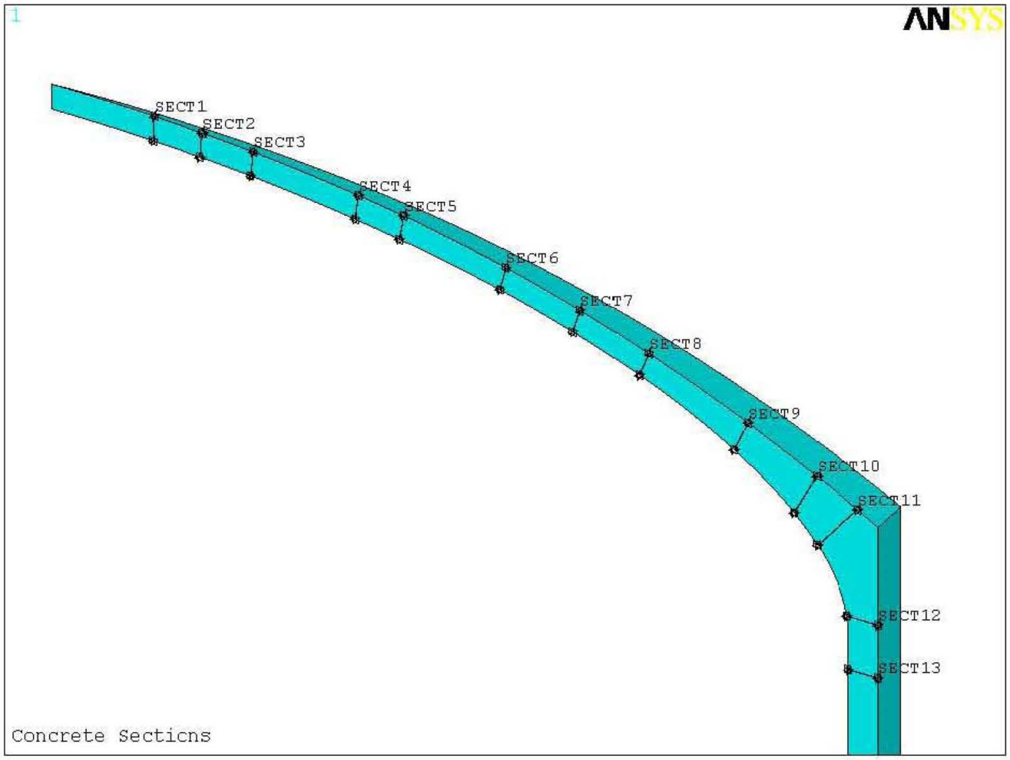

Figure 6-1. Reinforced Concrete Sections – Dome and Haunch Area

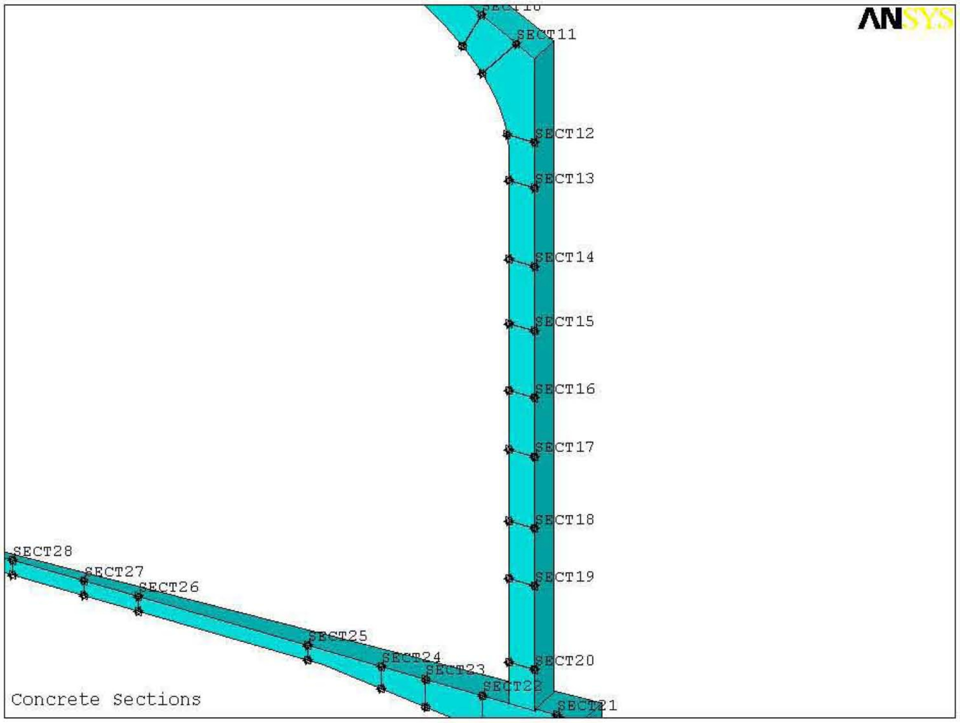

Figure 6-2. Reinforced Concrete Sections – Wall

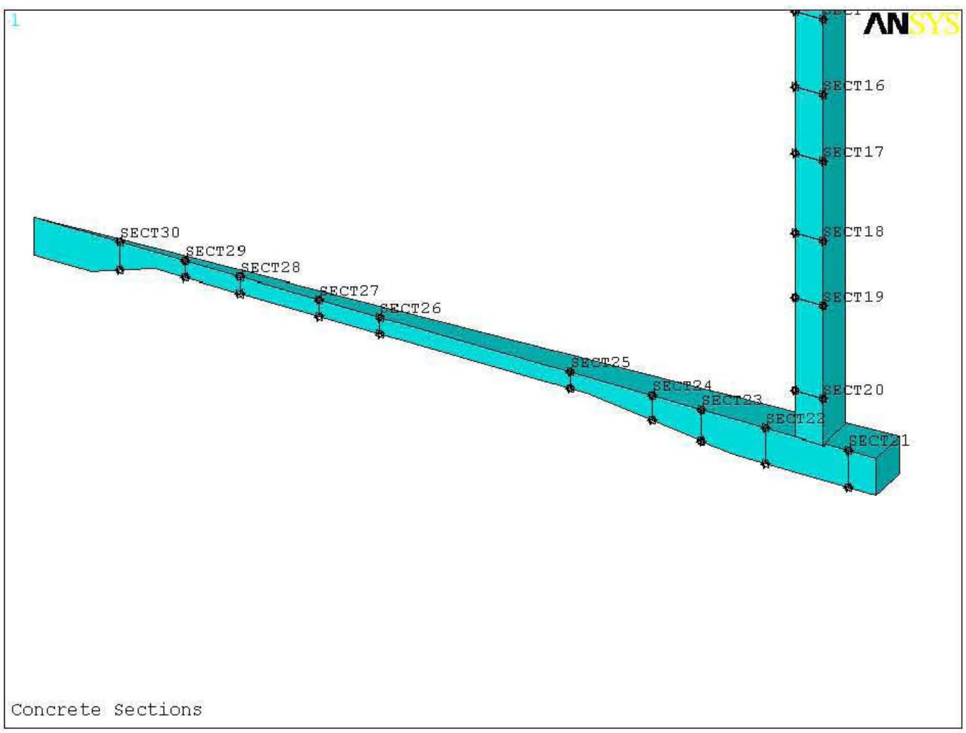

Figure 6-3. Reinforced Concrete Sections – Slab

6.1.2 Upper Bound Soil – Best Estimate Concrete

Figures 6-8 through 6-15 show the demand/capacity ratios for load combinations 1, 4, and 9 of the Upper Bound Soil – Best Estimate Concrete (UBS-BEC) material combination. The demand/capacity ratios are all less than 1.0 in all directions.

6.1.3 Lower Bound Soil – Best Estimate Concrete

Figures 6-16 through 6-19 show the demand/capacity ratios for load combination 4 of the Lower Bound Soil – Best Estimate Concrete (LBS-BEC) material combination. The demand/capacity ratios are all less than 1.0 in all directions.

6.1.4 Best Estimate Soil – Fully Cracked Concrete

Figures 6-20 through 6-23 show the demand/capacity ratios for load combination 4 of the Best Estimate Soil – Fully Cracked Concrete (BES-FCC) material combination. The demand/capacity ratios are all less than 1.0 in all directions.

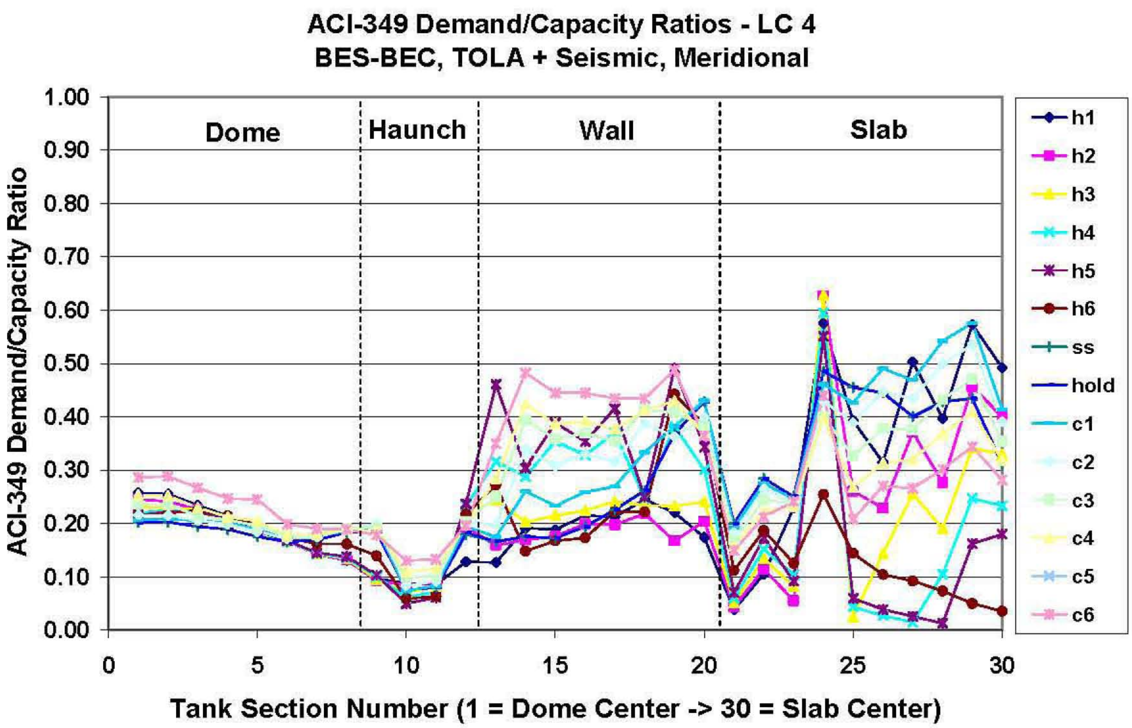

Figure 6-4. BES – BEC, Load Combination 4, Meridional

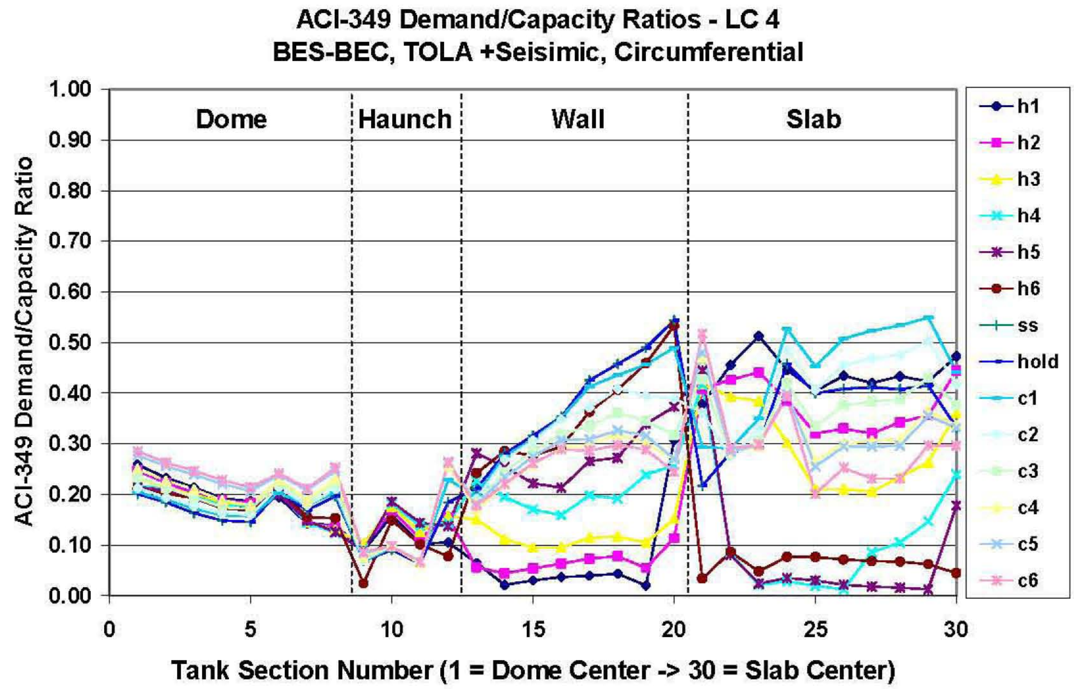

Figure 6-5. BES – BEC, Load Combination 4, Circumferential

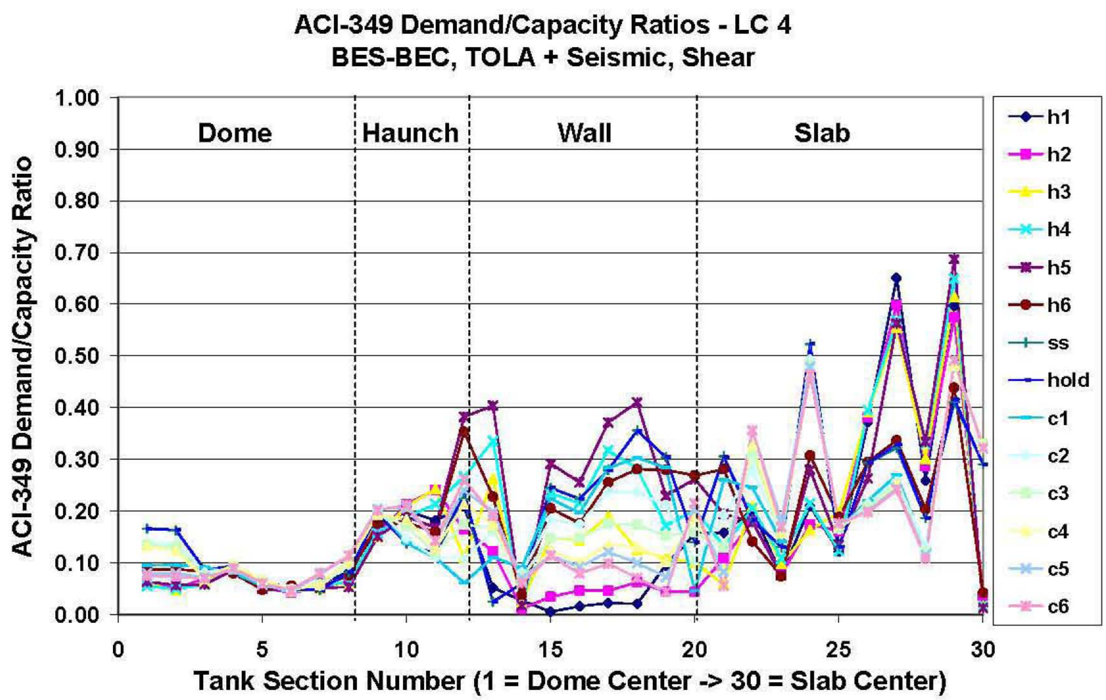

Figure 6-6. BES – BEC, Load Combination 4, Shear

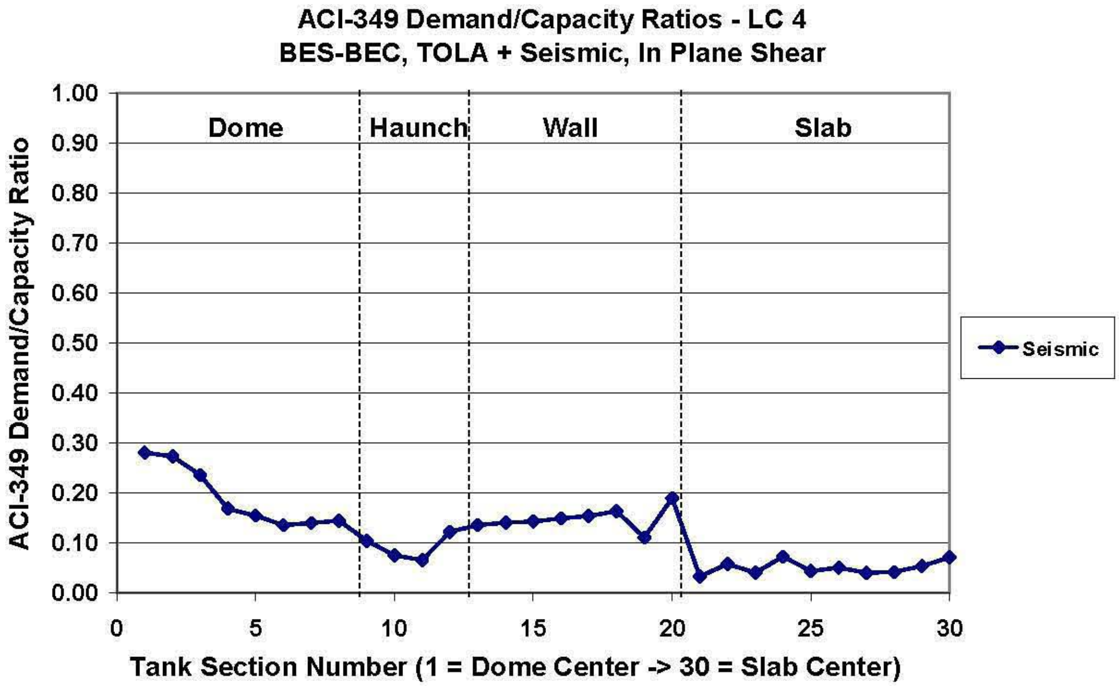

Figure 6-7. BES – BEC, Load Combination 4, In-Plane Shear

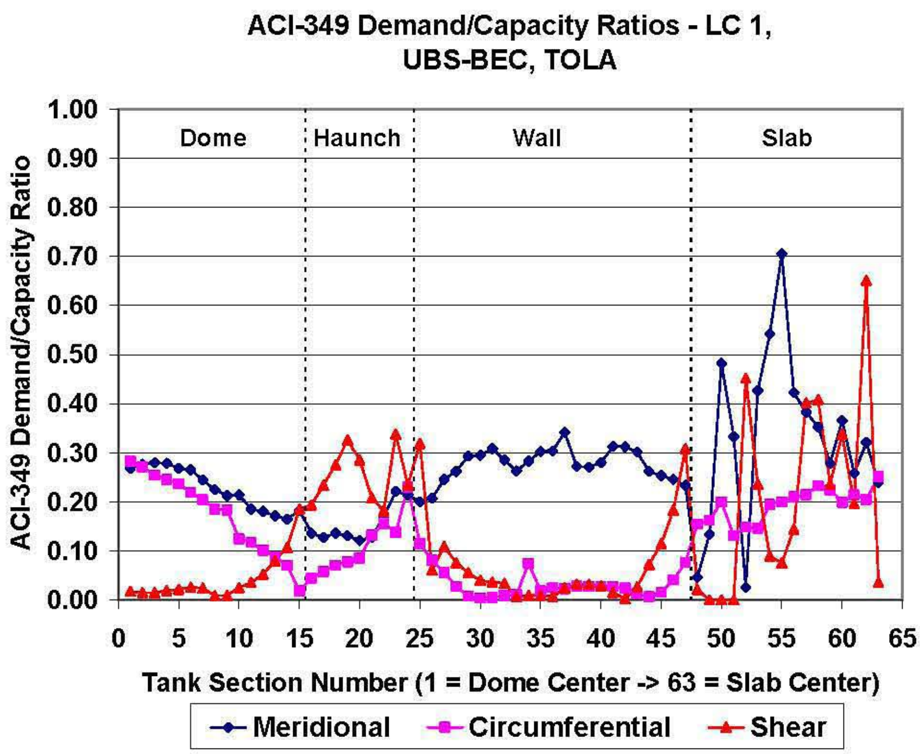

Figure 6-8. UBS – BEC, Load Combination 1

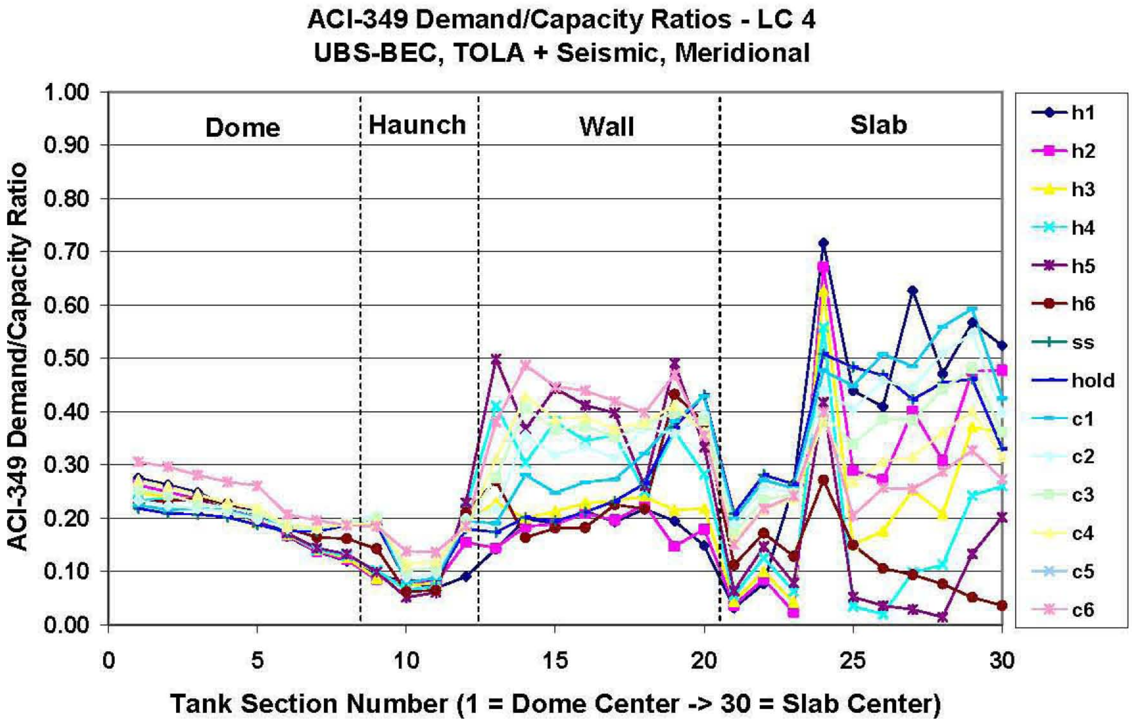

Figure 6-9. UBS – BEC, Load Combination 4, Meridional

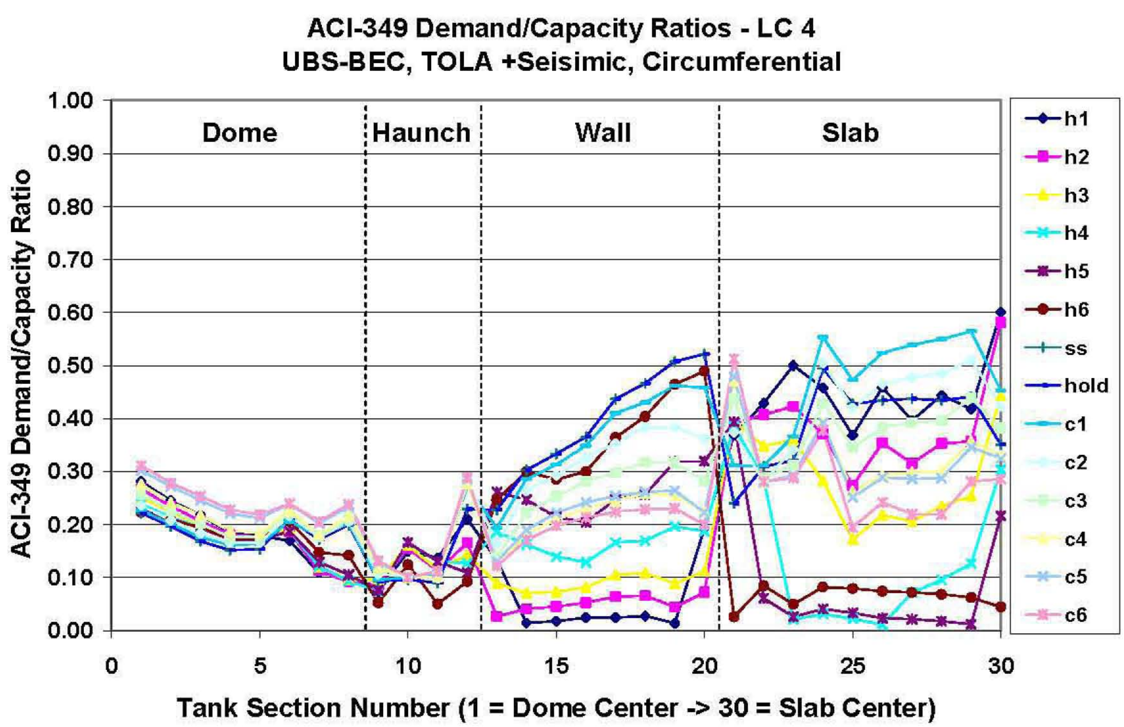

Figure 6-10. UBS – BEC, Load Combination 4, Circumferential

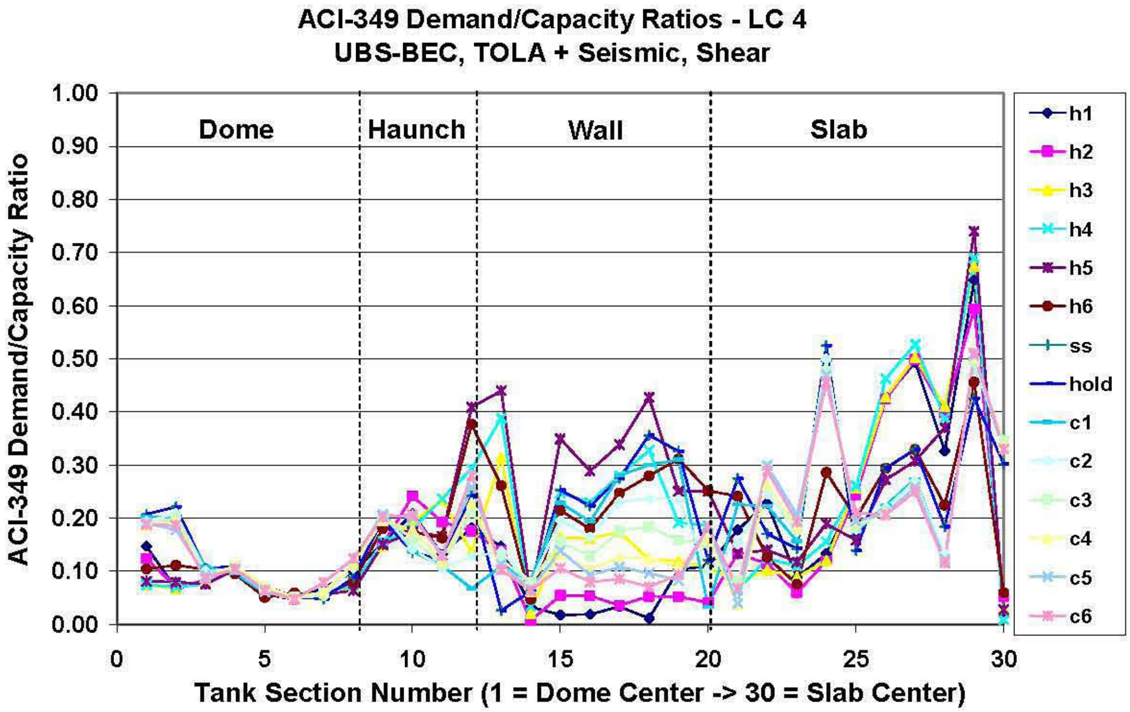

Figure 6-11. UBS – BEC, Load Combination 4, Shear

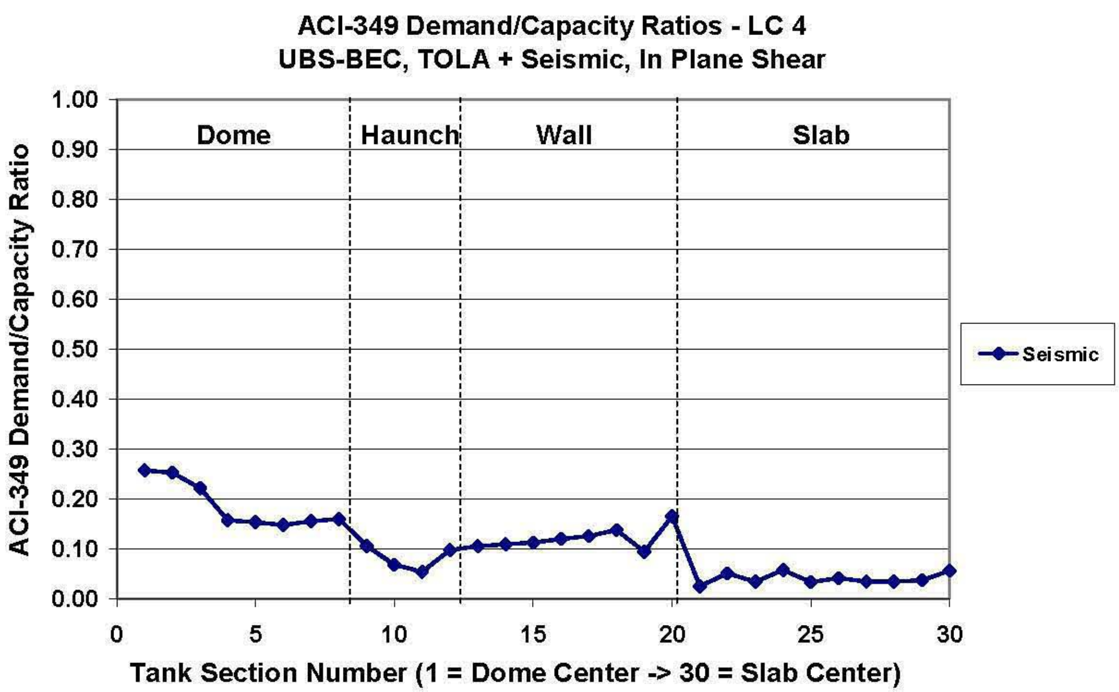

Figure 6-12. UBS – BEC, Load Combination 4, In-Plane Shear

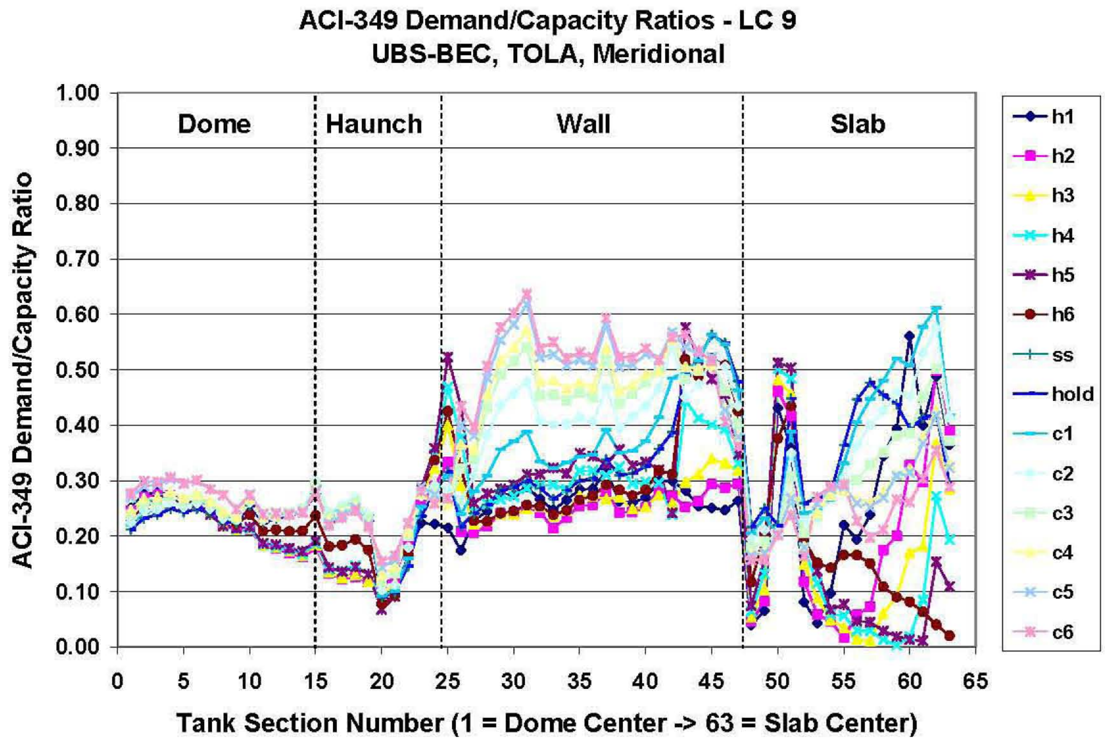

Figure 6-13. UBS – BEC, Load Combination 9', Meridional

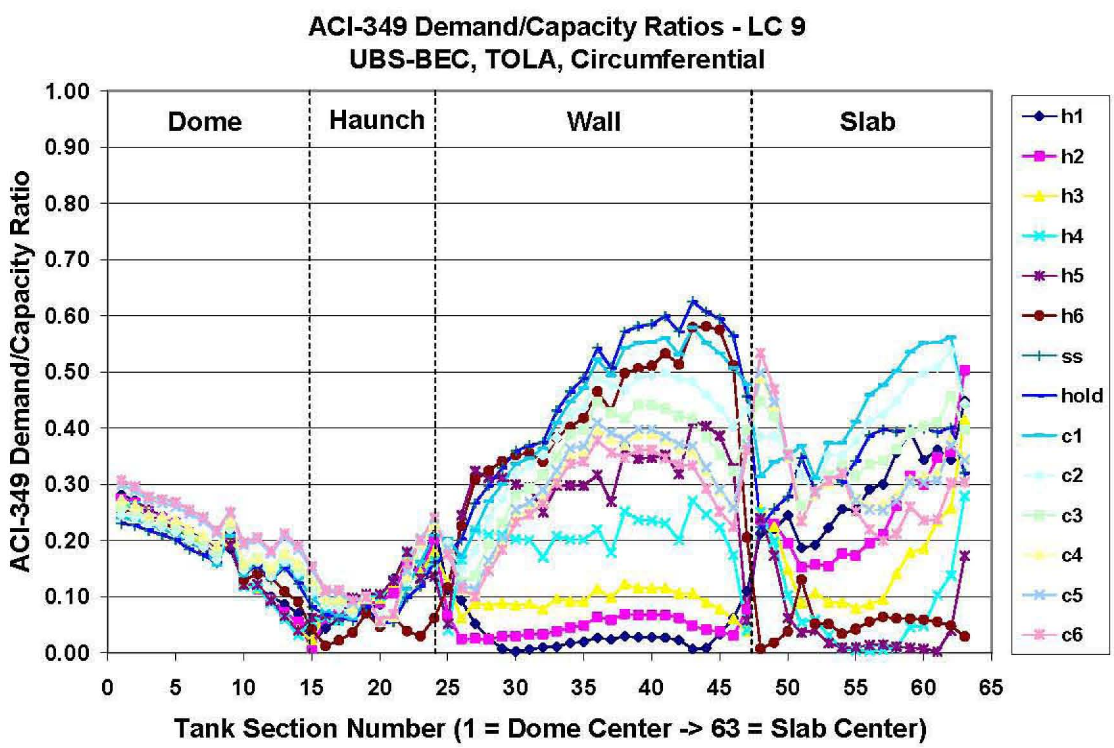

Figure 6-14. UBS – BEC, Load Combination 9', Circumferential

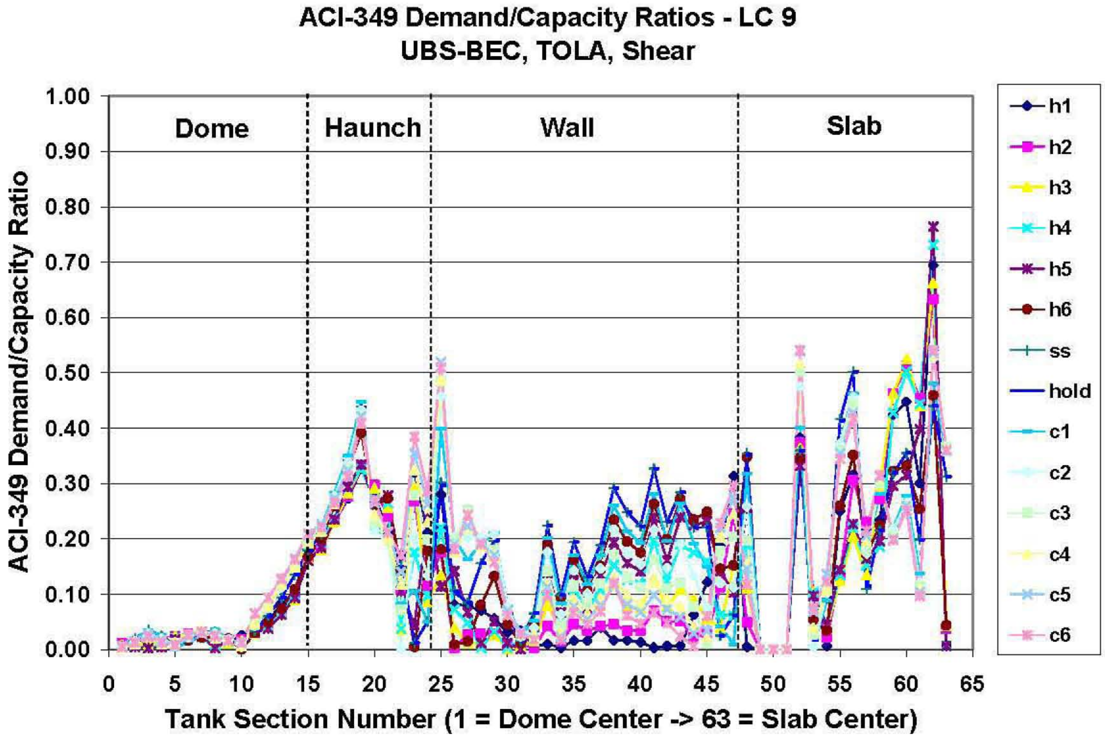

Figure 6-15. UBS – BEC, Load Combination 9', Shear

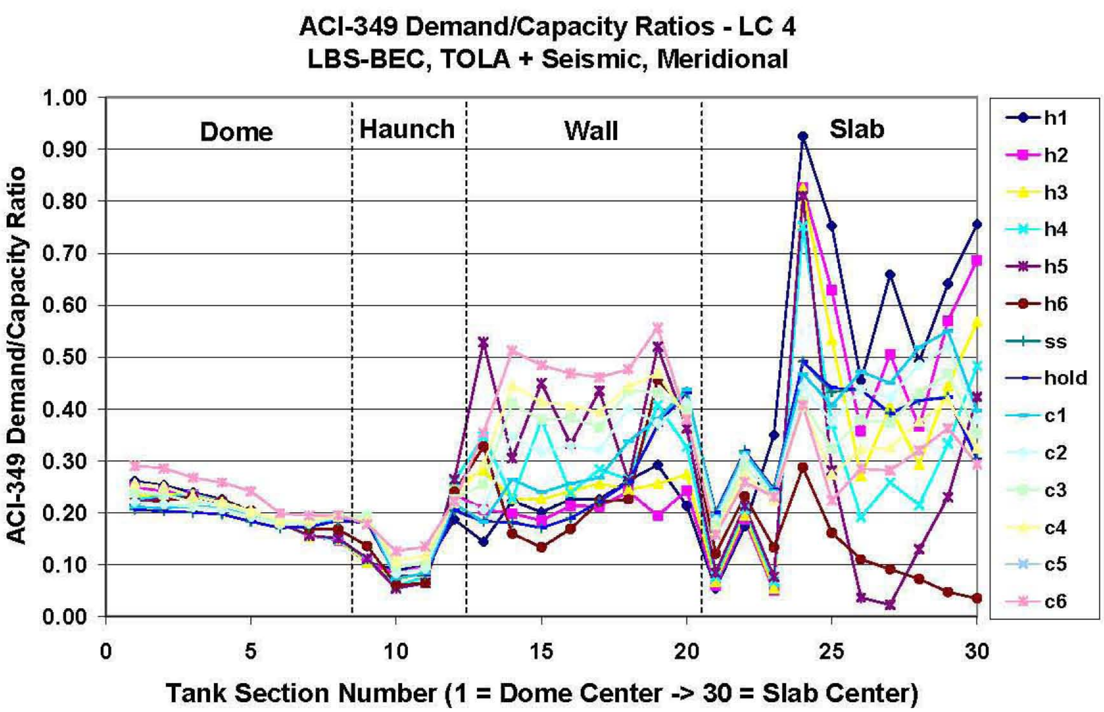

Figure 6-16. LBS – BEC, Load Combination 4, Meridional

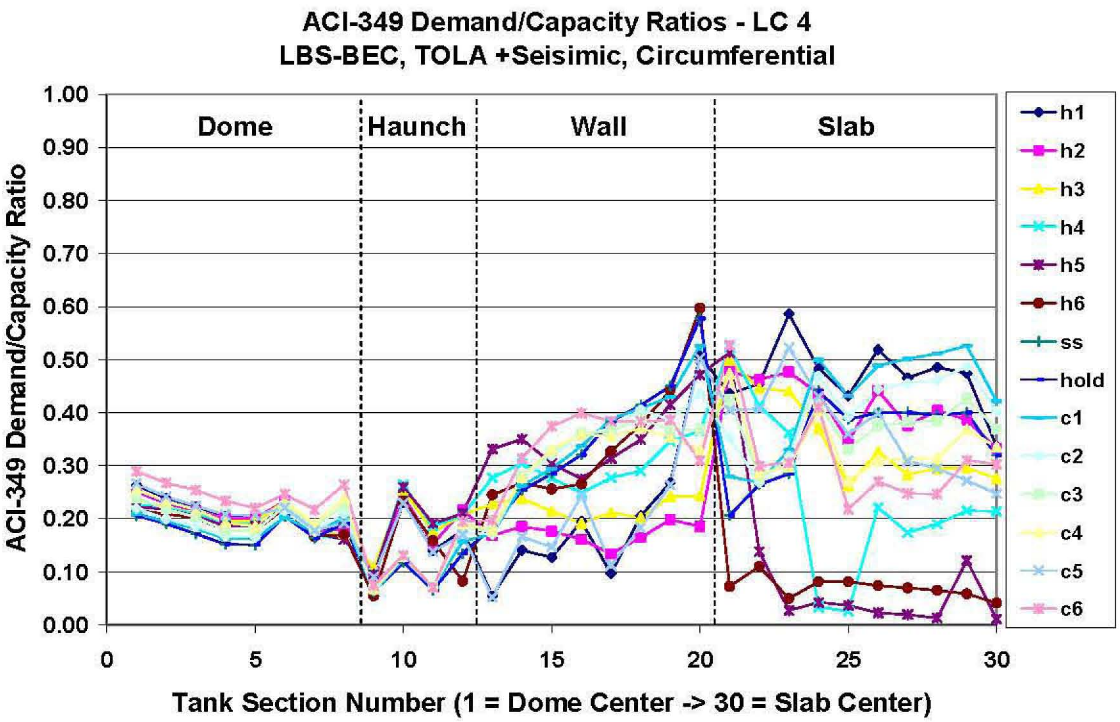

Figure 6-17. LBS – BEC, Load Combination 4, Circumferential

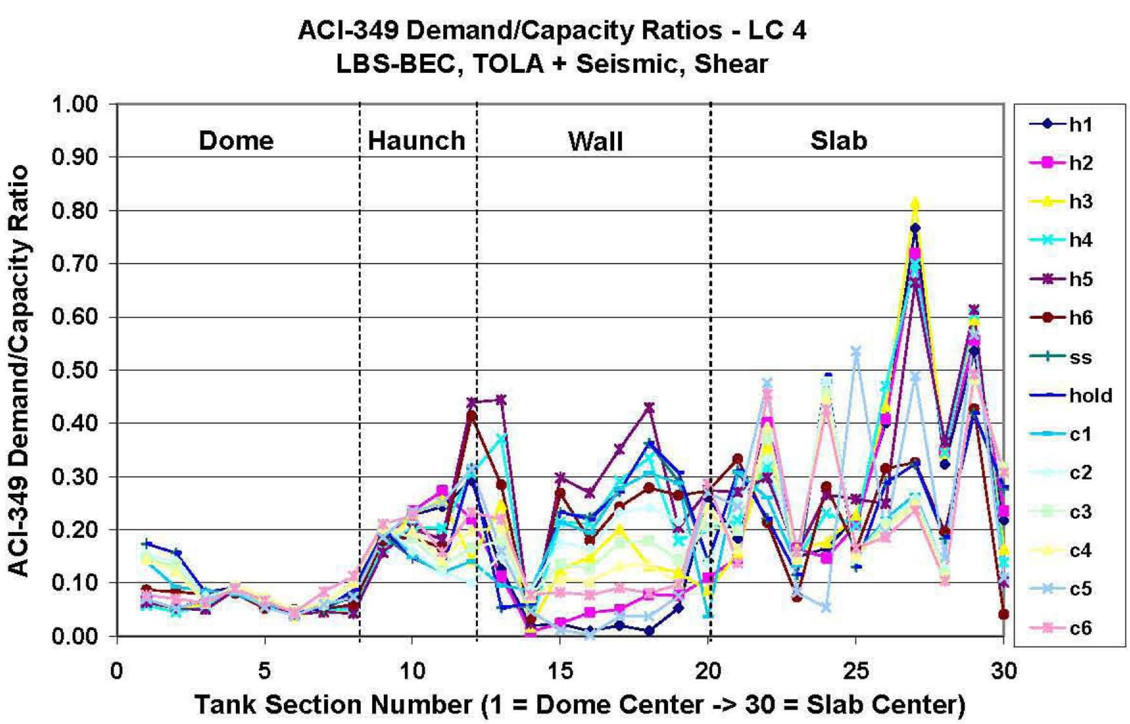

Figure 6-18. LBS – BEC, Load Combination 4, Shear

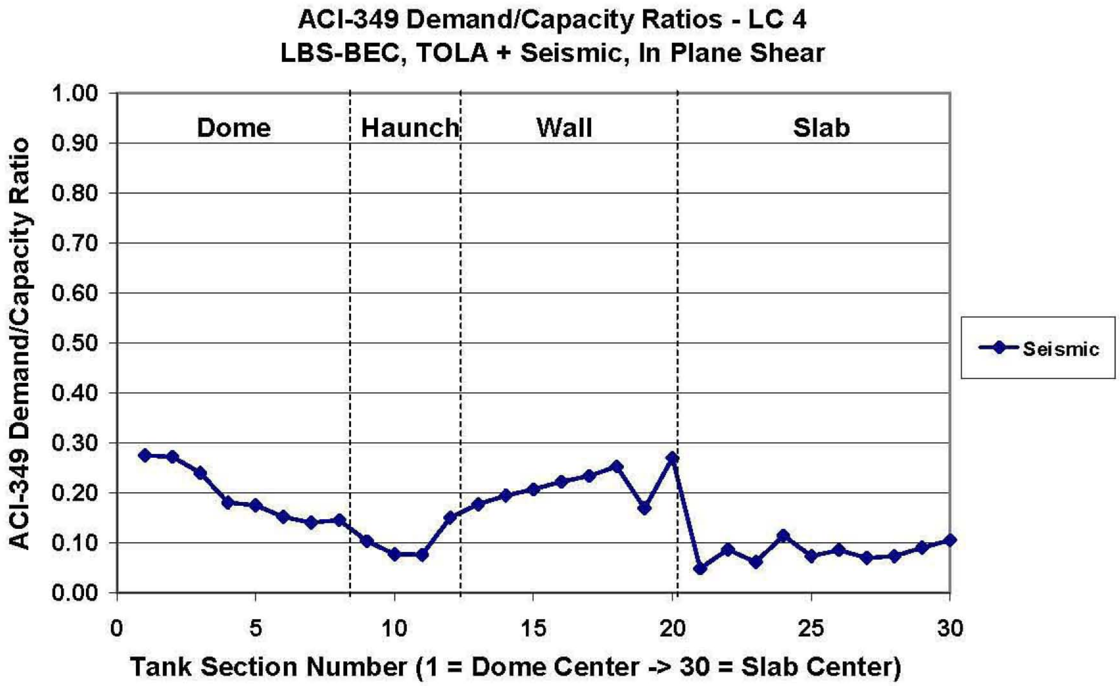

Figure 6-19. LBS – BEC, Load Combination 4, In-Plane Shear

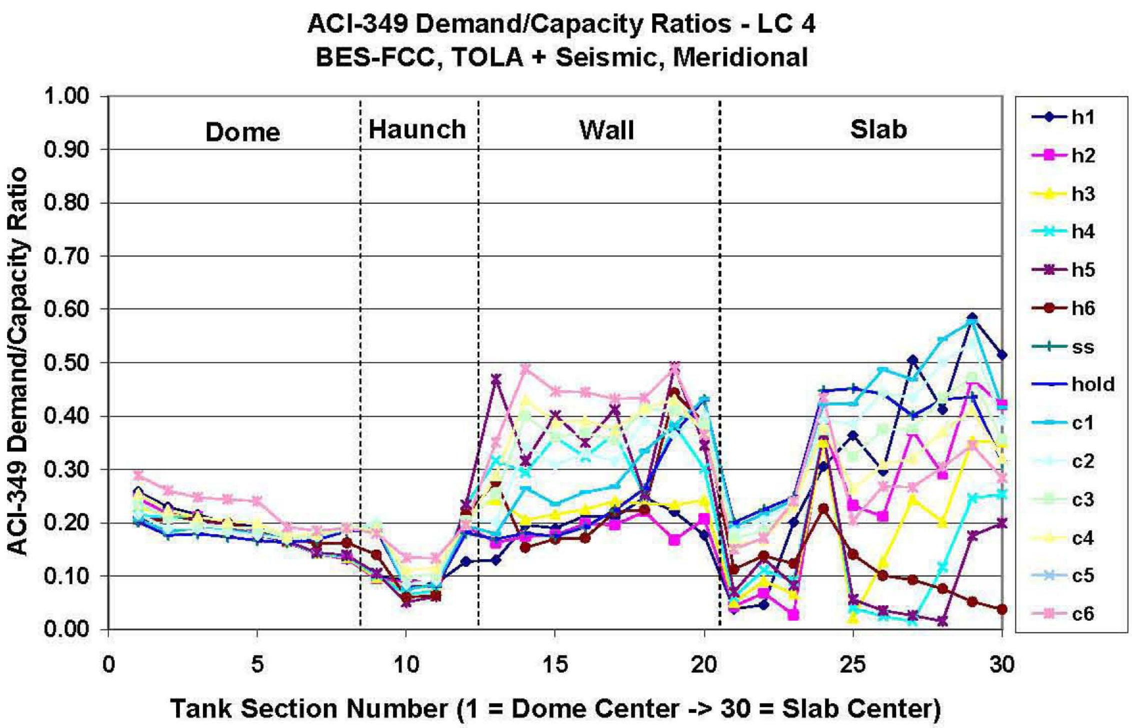

Figure 6-20. BES – FCC, Load Combination 4, Meridional

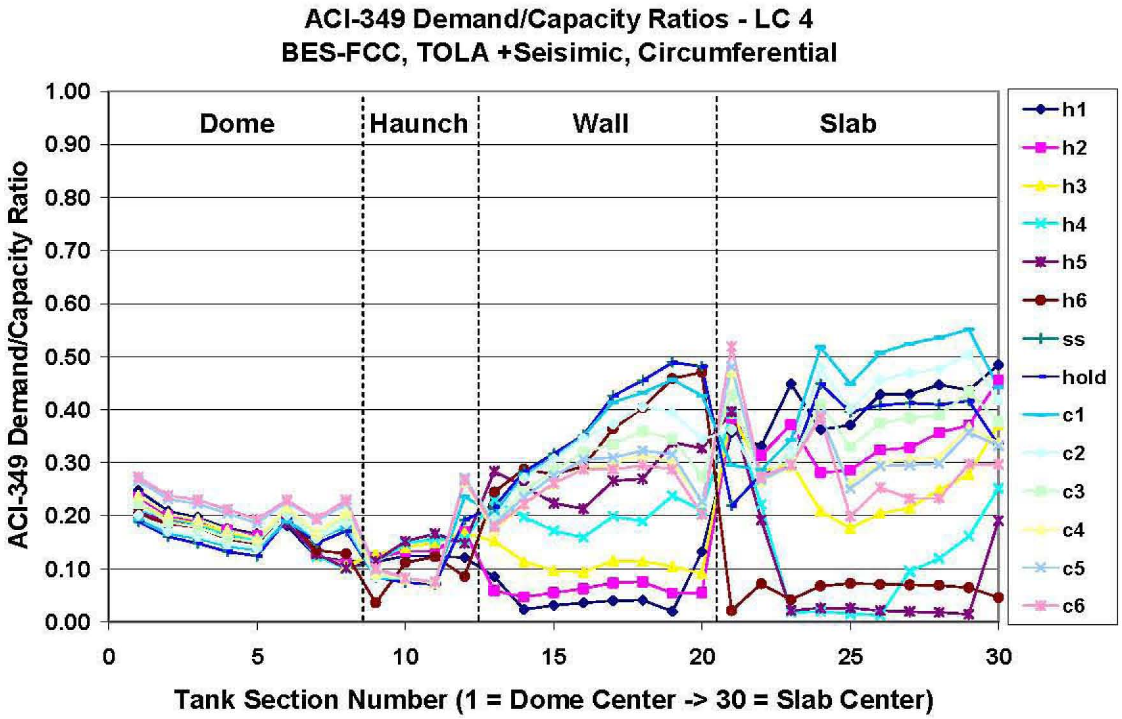

Figure 6-21. BES – FCC, Load Combination 4, Circumferential

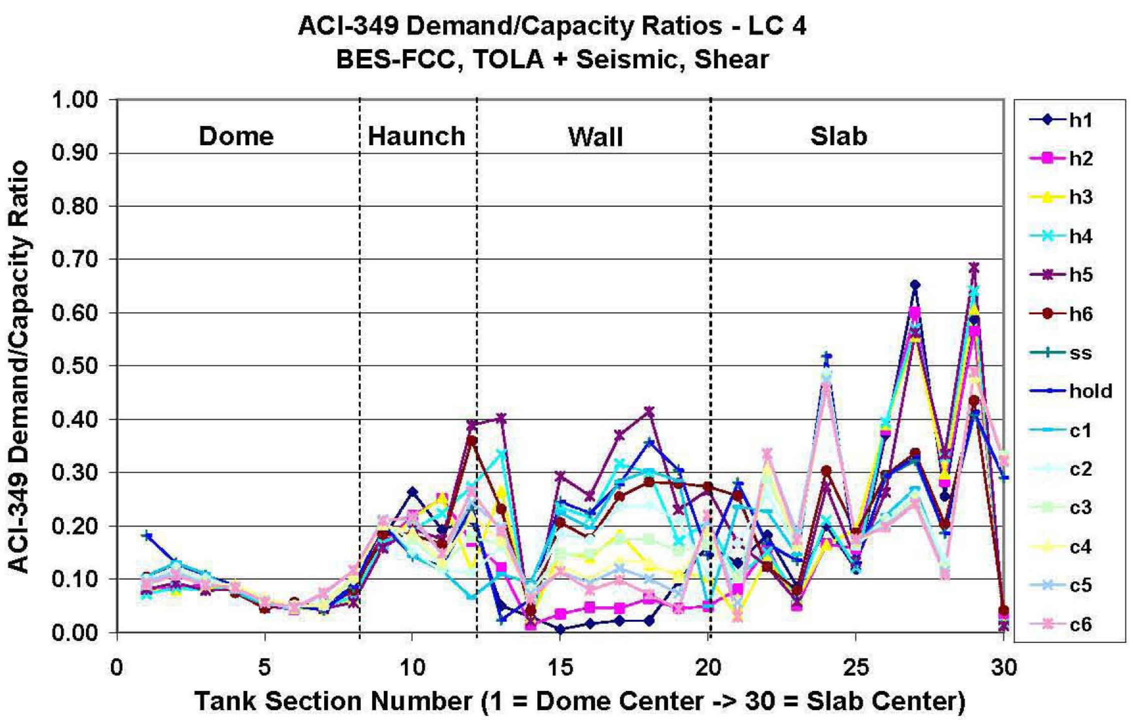

Figure 6-22. BES – FCC, Load Combination 4, Shear

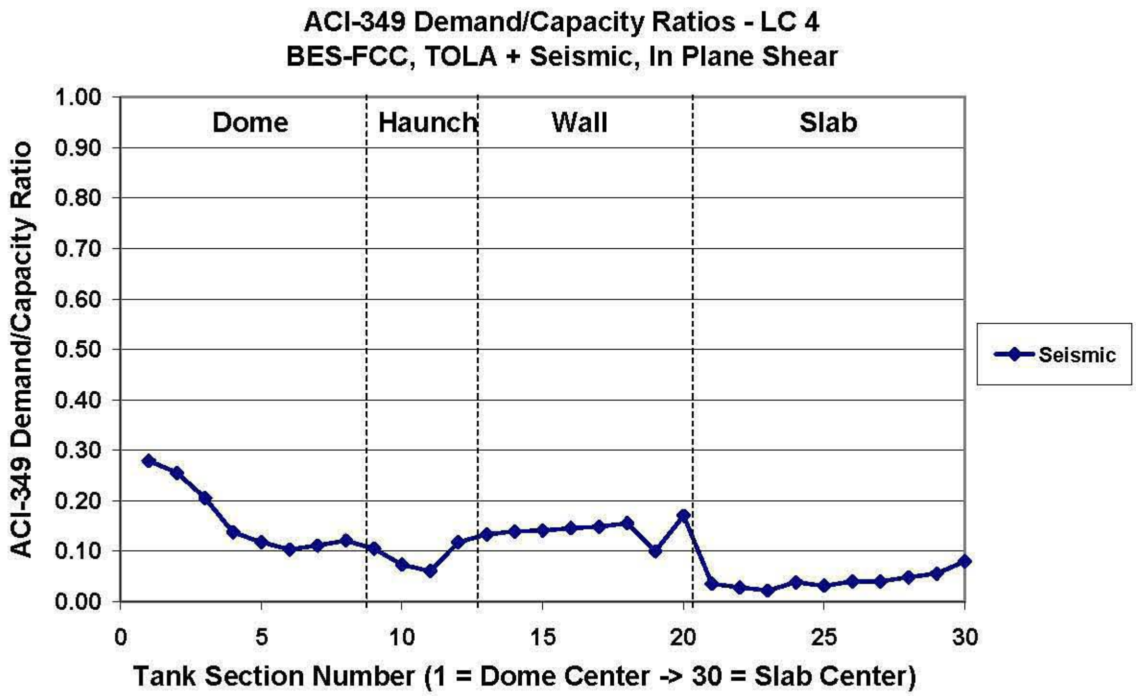

Figure 6-23. LBS – BEC, Load Combination 4, In-Plane Shear

6.2 ASME Primary Tank Evaluation

The primary tank was evaluated against the requirements of ASME B & PV Code, Section III, Division 1, Subsection NC, Article NC-3200 (ASME 1992a). Section 1622 of the IBC mandates that non-building structures meet the requirements of Section 9.14 of ASCE 7. That document, in turn, references the ASME B & PV Code as the applicable standard. Therefore, while the DST primary tank structure is not specifically addressed in IBC, they can be shown to meet the requirements of IBC by demonstrating their compliance with the ASME code.

The Evaluation Criteria document (Day el al. 1995) states that earthquake loads may be considered as Service Level D loading. The Seismic Design and Evaluation document (Bandyopadhyay et al. 1995) also states that load combinations including the design-basis earthquake should use Service Level D capacities.

The TOLA analysis (Rinker et al. 2004) conservatively evaluated the primary tank using Section VIII, Division 2 of the ASME code. This approach is considered conservative because the level of detail included in the analysis supports the use of Section III, Division 1, NC-3200 capacities. Similarly, the seismic analysis of the tanks (Abatt and Rinker 2008) is of a level of detail also consistent with the use of ASME Section III, Division 1, NC-3200 capacities.

6.2.1 Primary Tank Results

The general primary membrane stress intensity, the general primary membrane plus bending stress intensity and the primary plus secondary stress intensity range are shown in Figures 6-24 through 6-43. The demands are well within the allowable capacity for each of the four material combinations.

It was stated in Section 3.2.7 of this report that the ANSYS seismic model has some limitations for predicting the convective response of the waste. Comparisons of primary tank element hoop stresses near the waste free surface from Dytran and ANSYS models were presented in Abatt (2006), and Carpenter and Abatt (2006), respectively. The models showed that at the 422 in. waste level, where the interaction of the fluid with the dome curvature is not significant, that the primary tank hoop stresses near the free surface were less than 5 kip/in^2 in magnitude, and that the stresses predicted by ANSYS and Dytran were similar. Because of the low demand to capacity ratio near the free surface and the similarity in the stresses reported by the two codes, the stresses extracted from the ANSYS simulation are sufficient to evaluate the stresses in the primary tank near the free surface.

The current Operating Specifications (Knight 2005) specifies a specific gravity limit of 2.0 at 372 in. of waste for the AY and AZ tanks. The bounding analysis reported herein evaluates the tanks at a specific gravity of 1.7 at 422 in. of waste. It was desired to qualify the AY and AZ tanks at this different waste condition. The primary stress in the tank wall is hoop tension which varies linearly with the hydrostatic load. Consequently, a linear scaling of the general primary membrane stress intensity results in a demand/capacity ratio of 0.78. Therefore the primary tank of the AY/AZ tanks with 372 in. of 2.0 SpG waste can be judged to be satisfactory.

6.2.2 Evaluation Criteria Discussion

The evaluation of the primary tank capacity was in accord with ASME Section III, Division 1, Service Level D as specified by the Structural Acceptance Criteria document (Day et al. 1995) and the guidance of the Seismic Evaluation document (Bandyopadhyay et al. 1995). The ASME code specifies the following load combinations and capacities for an elastic analysis:

General primary membrane stress intensity $P_m \leq kS_m$ (6.1)

Local primary membrane stress intensity $P_L \leq 1.5kS_m$ (6.2)

Primary membrane + bending stress intensity $(P_m \text{ or } P_L) + P_b \leq 1.5kS_m$ (6.3)

Primary + secondary stress intensity $(P_m \text{ or } P_L) + P_b + Q \leq 3S_m$ (6.4)

In these equations, P_m is the primary membrane stress, P_L is the local primary stress, P_b is the primary bending stress, and Q is a secondary stress (thermal in the case of the DSTs). The factor k is equal to 2.0 for Service Level D capacities.

The general primary membrane stress in the DST primary tank is dominated by hoop tension. Section 5.5 of the Seismic Evaluation document (Bandyopadhyay et al. 1995) imposes the additional condition that the hoop membrane stress capacity should be taken as the ASME Section III, Division 1, Service Level D limit of $2S_m$, or the yield strength, whichever is less. The intent of the additional condition is that kS_m should be limited to the yield strength if credit is taken for inelastic energy absorption in the computation of demands. Accordingly, the general primary membrane stress intensity criterion becomes:

$$P_m \leq \min(kS_m, S_y) \tag{6.5}$$

This additional condition was invoked for each of the DST evaluations shown in Figures 6-24, 6-29, 6-34, and 6-39.

6.2.3 Additional Considerations

DOE-STD-1020 governs the natural phenomenon hazards assessment and provides additional guidelines for evaluation of existing structures at DOE facilities. More specific requirements for the DSTs are given in the Structural Acceptance Criteria document (Day et al. 1995). The DST seismic demand and capacity are addressed in the Seismic Design and Evaluation document (Bandyopadhyay et al. 1995). Other codes and standards such as the International Building Code (IBC 2003) and Minimum Design Loads for Buildings and other Structures (ASCE 7-02) are more general in their application and do not specifically address underground waste storage tanks. The DST primary tanks were originally designated as Safety Class 1 structures, but have been downgraded to Performance Class (PC-2) structures (RPP-13033). According to DOE-STD-1020, the seismic design and evaluation of PC-2 structures should be governed by the current version of the IBC. The designation of the tanks as PC-2 structures puts new emphasis on model building codes for the seismic evaluation of the DSTs, even though the codes were not developed specifically to apply to such tanks.

The AZ and SY primary tanks were designed to Section III, Division I of the ASME Boiler & Pressure Vessel code, while the AY, AW, AN, and AP tanks were designed to Section VIII, Division 2 of the ASME code. The interplay between the various codes and standards as well as the implementation of both Sections III and VIII of the ASME code as the design code of record complicates the selection of the acceptance criteria for seismic evaluation of the primary tanks. The analysis must guard against inappropriate combinations of factors and methods from the different standards. The current analysis attempts to utilize a conservative method while not being overly restrictive on either the demand or the capacity.

The IBC method allows for the elastically calculated seismic demand to be divided by the quantity (R/I) consistent with IBC Section 1618 and ASCE 7-02 Section 9.5.7, where R is a response modification coefficient and I is the occupancy importance factor. This reduced seismic demand is referred to as the factored inelastic demand. The applicable importance factor is 1.5 as determined from IBC Table 1604.5 or from Table 2-1 of DOE-1020. Table 9.14.5.1.1 of ASCE gives response modification coefficients of 2.5 and 3.0 for self-anchored and mechanically anchored flat bottom ground supported steel tanks. The value of 2.5 was selected as appropriate for the DST evaluation. This combination gives a (R/I) value of (2.5/1.5), or 1.67, resulting in a 40% reduction in the elastically computed seismic stresses.

Although an inelastic factor of 1.67 is permitted by the IBC, it was not used in this evaluation. That is, not only was the general primary membrane stress limited to the yield stress, but the seismic (and non-seismic) demands were left unfactored. Accordingly, while the use of the IBC and ASME Service Level D demands and capacities does allow for the possibility of gross plastic deformation, this analysis shows the primary tank general membrane stress during a seismic event to be less than yield.

Several factors could demonstrate further decreases in the demand/capacity ratios if future analyses (e.g. increased liquid level or increased specific gravity) indicate reduced safety margins. The allowable stress values, either S_m or S_y, were taken at the design temperature of 350°F. Historical data reported in the TOLA report (Rinker et al. 2004) indicates none of the DSTs have ever experienced this level of temperature and current operating specifications provide even more stringent limits on waste temperature. While not dramatic, using the allowable stress at 250°F could provide at least an additional 5% margin. Furthermore, the allowable stress was based on the ASTM A515 steel used in the AY and AZ tanks.

Conducting tank specific analyses using the higher strength steels of the other tanks could significantly increase the safety margins.

There are two alternate ASME based approaches that are viable and generally accepted. The first is to use the elastically calculated seismic stresses in combination with the non-seismic stresses and invoke Eqn. 6.1 directly rather than using Eqn. 6.5. The second alternative is to compare the elastically computed stresses to the ASME Section III, Service Level D, Appendix F capacities. In the case of general primary membrane stress intensity, the Appendix F criterion is

$$P_{me} \leq \min(2.4S_m, 0.7S_u) \qquad (6.6)$$

Finally, the IBC provides guidance for the design and evaluation of new structures but does not address existing facilities. Accordingly, the site specific ground motion used for the DST seismic analysis is for a new PC-2 structure. However, DOE-STD-1020 (DOE 2002) provides relief by allowing evaluations using natural phenomena hazard exceedance probabilities of twice the value for a new design. Where it is not practical to undertake analysis based on double the probability, up to 20% reduction in forces may be permissible. This reduction in seismic demand on the DST's could also be applied if analyses show demand exceeding capacity with all the above mentioned factors already considered.

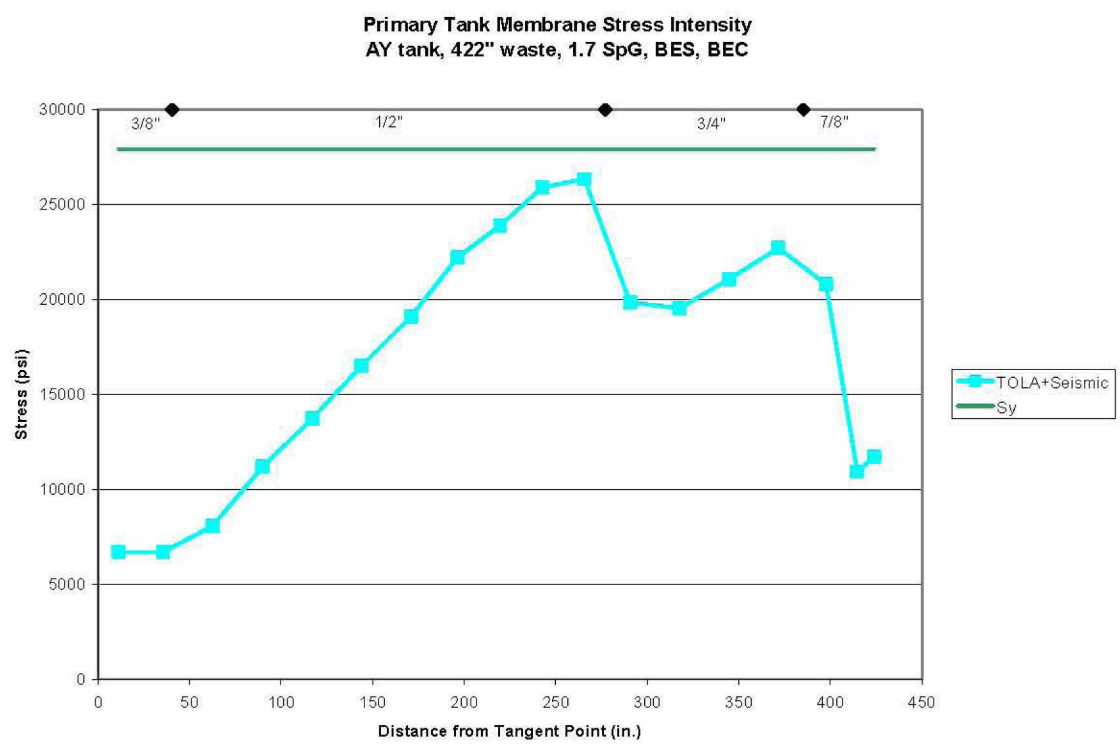

Figure 6-24. BES – BEC Primary Membrane Stress Intensity

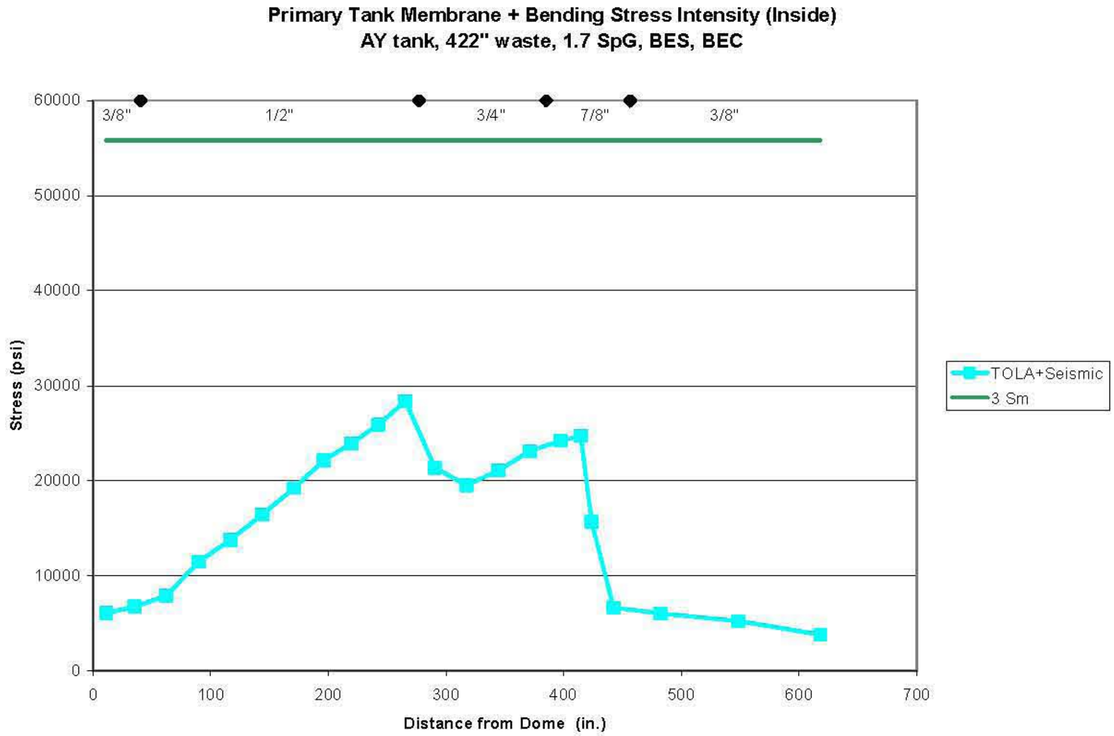

Figure 6-25. BES – BEC Primary Membrane + Bending (inside) Stress Intensity

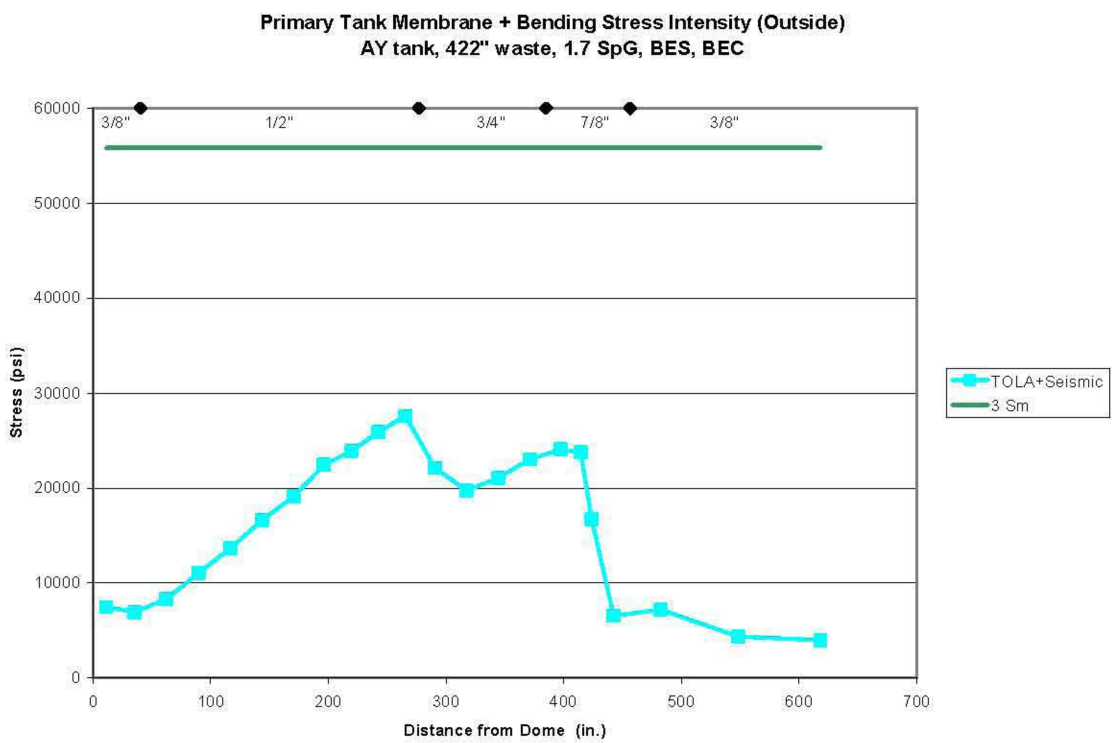

Figure 6-26. BES – BEC Primary Membrane + Bending (outside) Stress Intensity

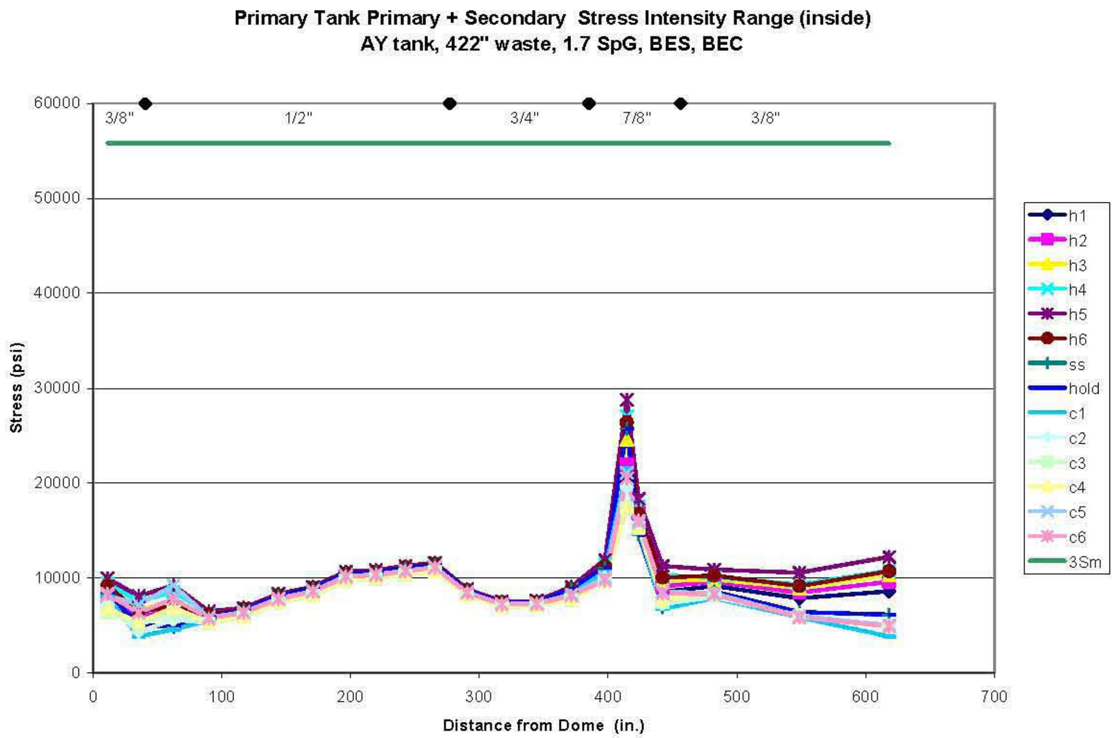

Figure 6-27. BES – BEC Primary + Secondary (inside) Stress Intensity Range

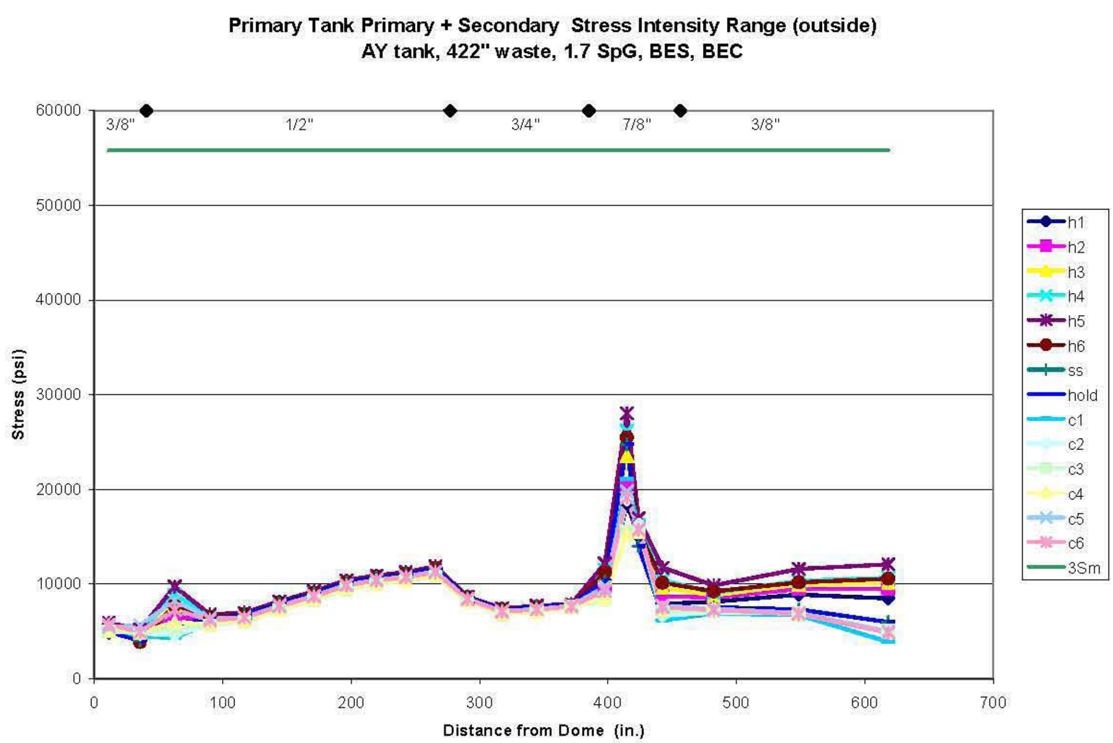

Figure 6-28. BES – BEC Primary + Secondary (outside) Stress Intensity Range

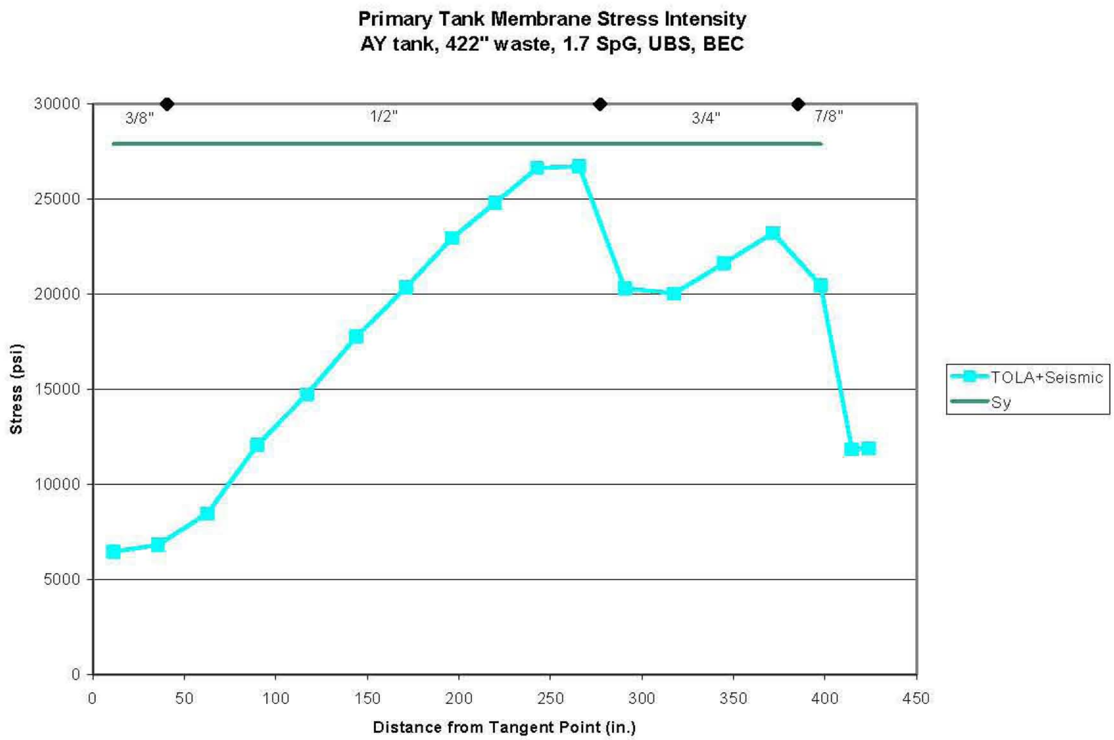

Figure 6-29. UBS – BEC Primary Membrane Stress Intensity

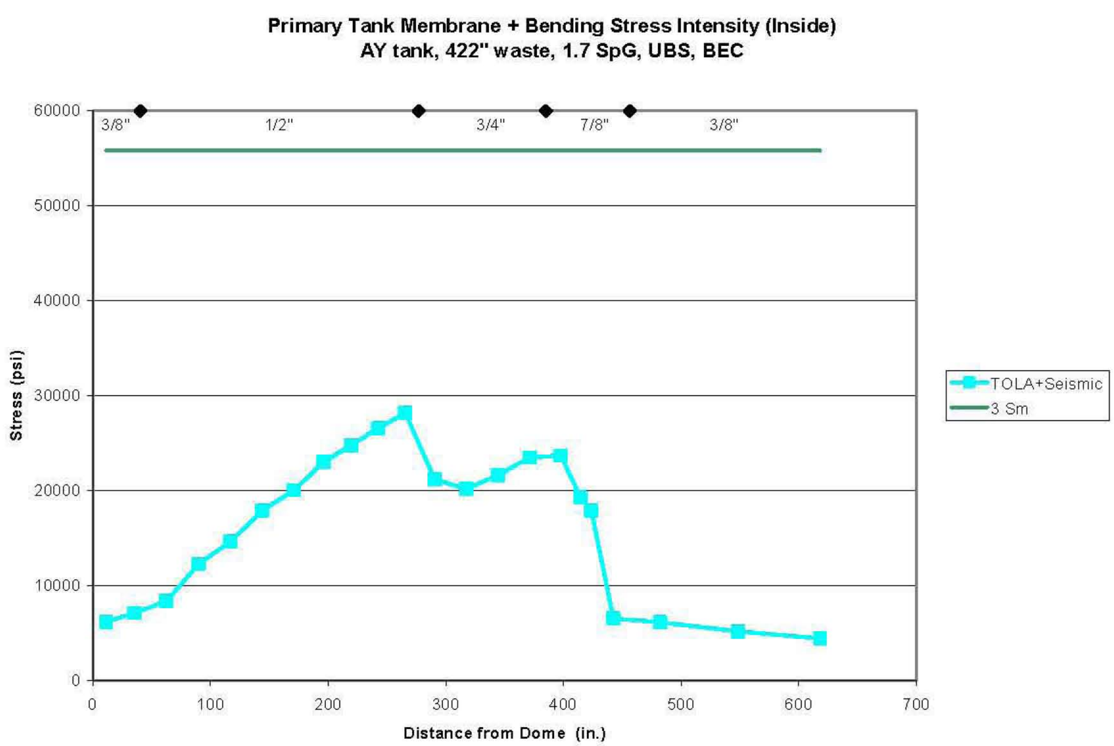

Figure 6-30. UBS – BEC Primary Membrane + Bending (inside) Stress Intensity

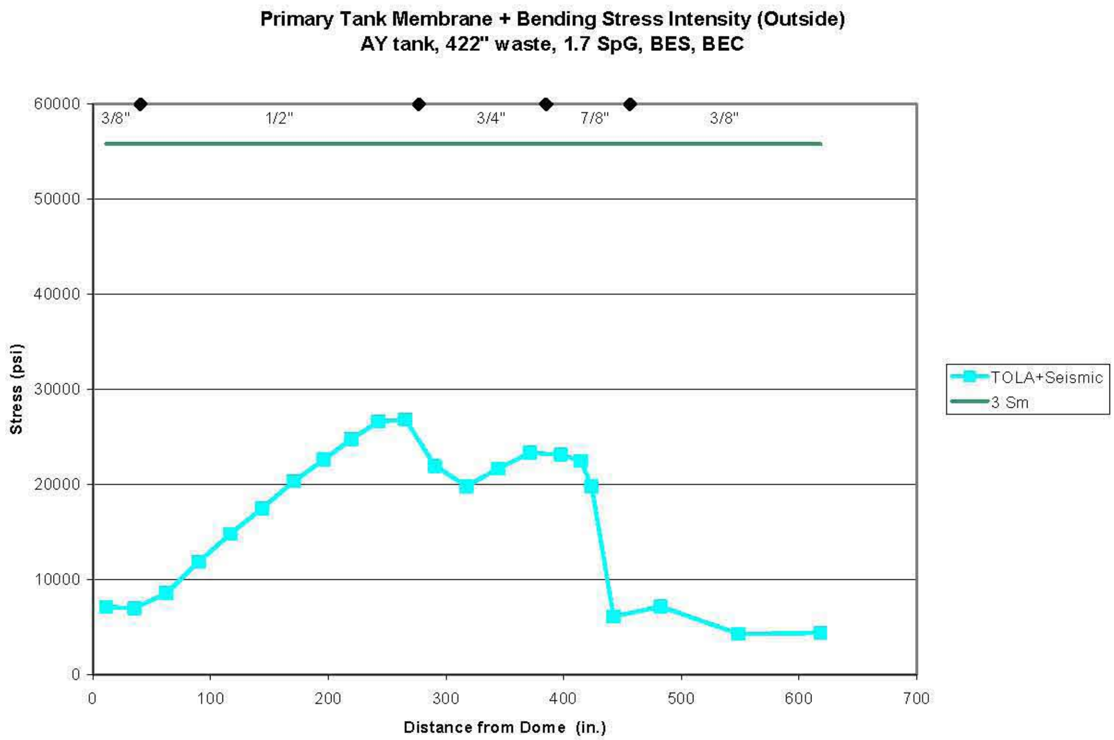

Figure 6-31. UBS – BEC Primary Membrane + Bending (outside) Stress Intensity

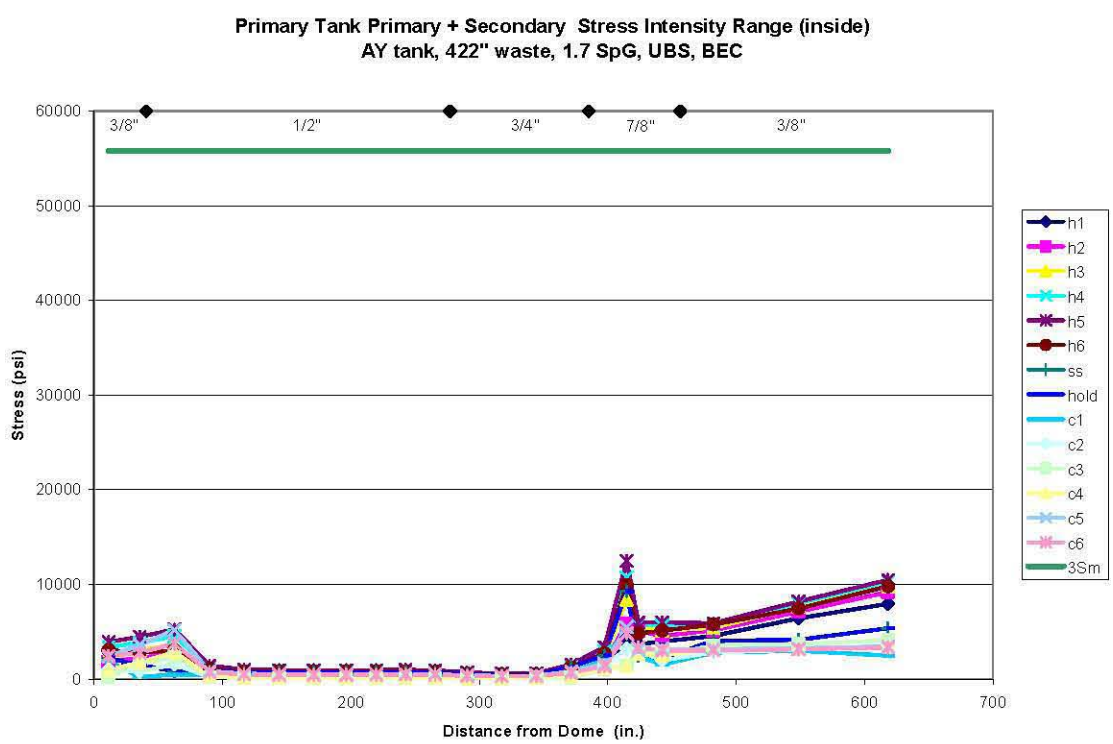

Figure 6-32. UBS – BEC Primary + Secondary (inside) Stress Intensity Range

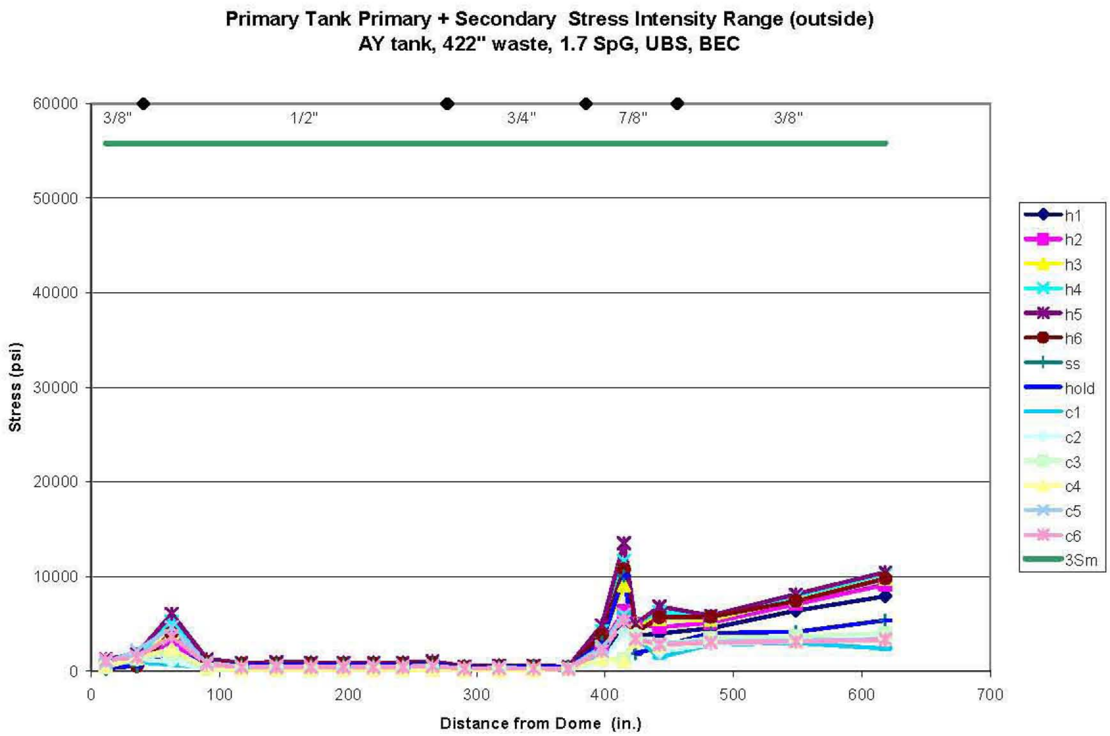

Figure 6-33. UBS – BEC Primary + Secondary (outside) Stress Intensity Range

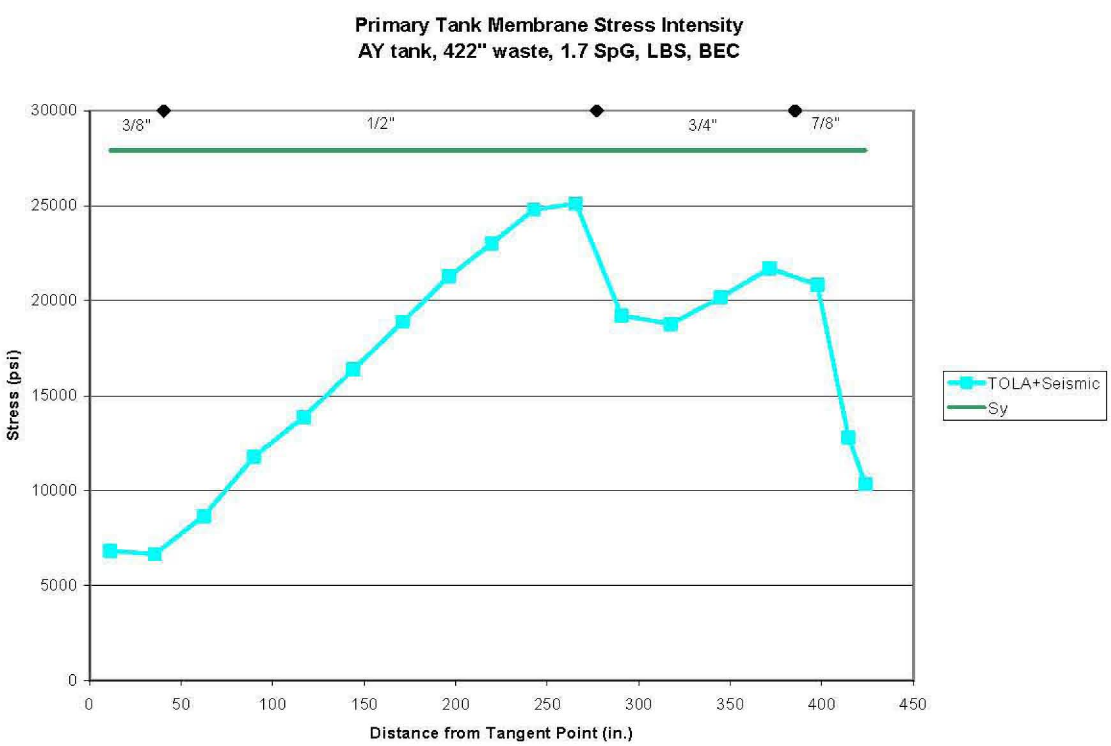

Figure 6-34. LBS – BEC Primary Membrane Stress Intensity

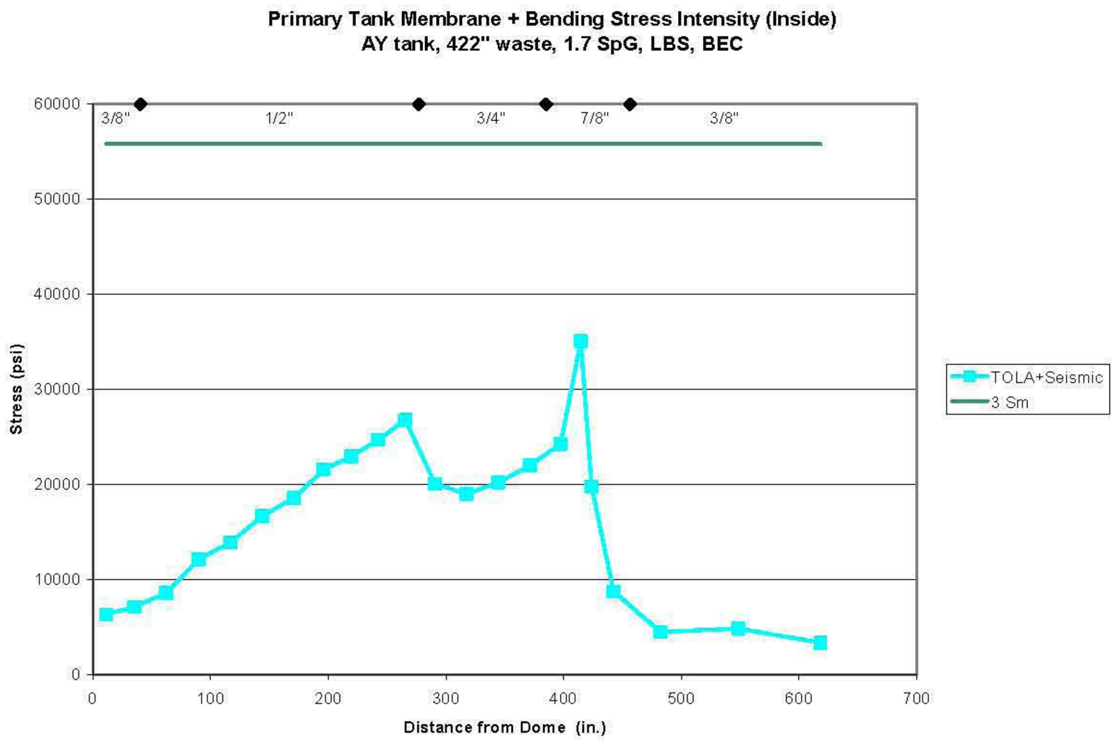

Figure 6-35. LBS – BEC Primary Membrane + Bending (inside) Stress Intensity

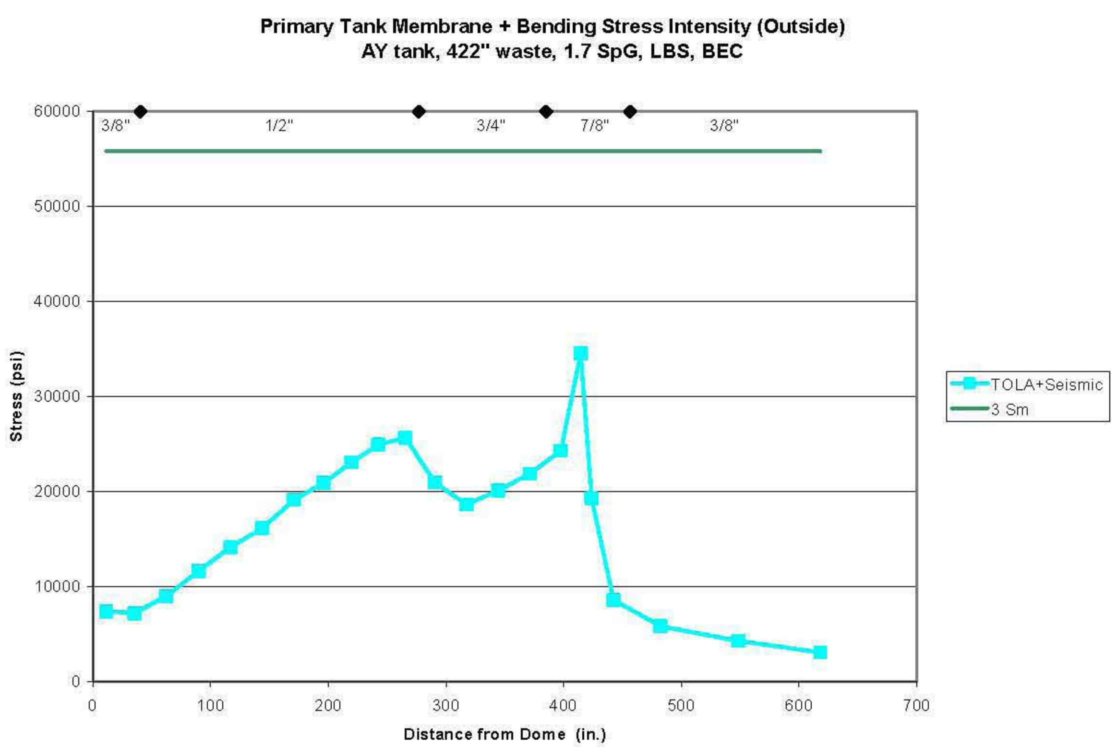

Figure 6-36. LBS – BEC Primary Membrane + Bending (outside) Stress Intensity

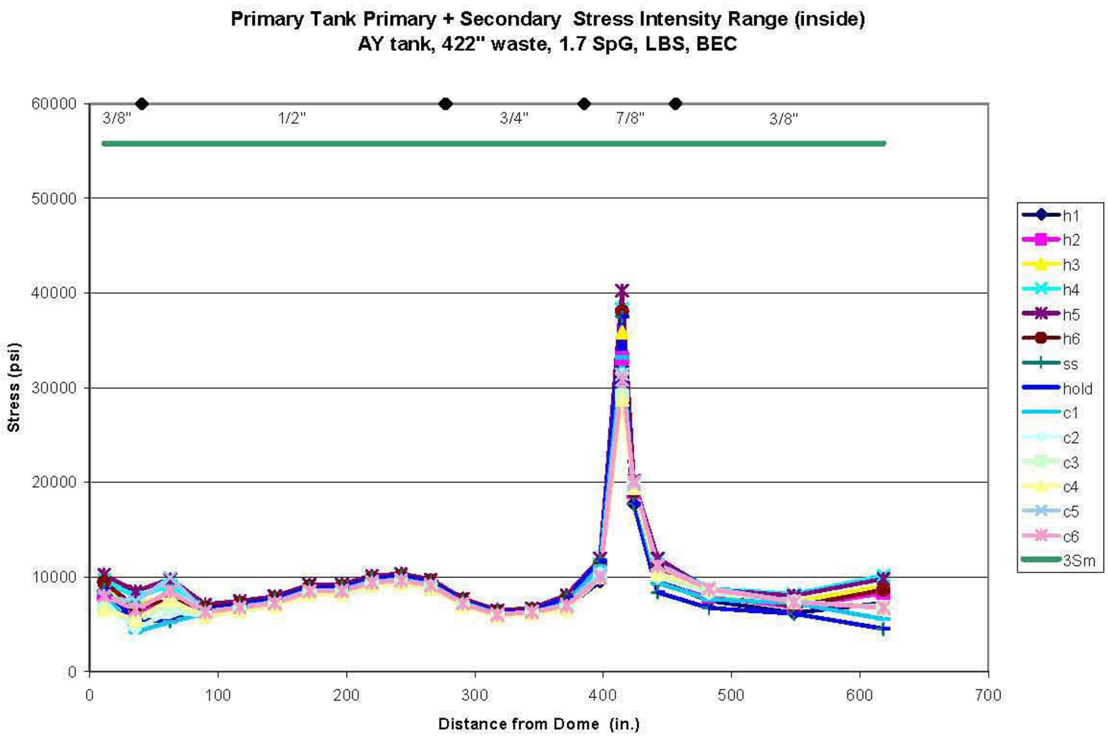

Figure 6-37. LBS – BEC Primary + Secondary (inside) Stress Intensity Range

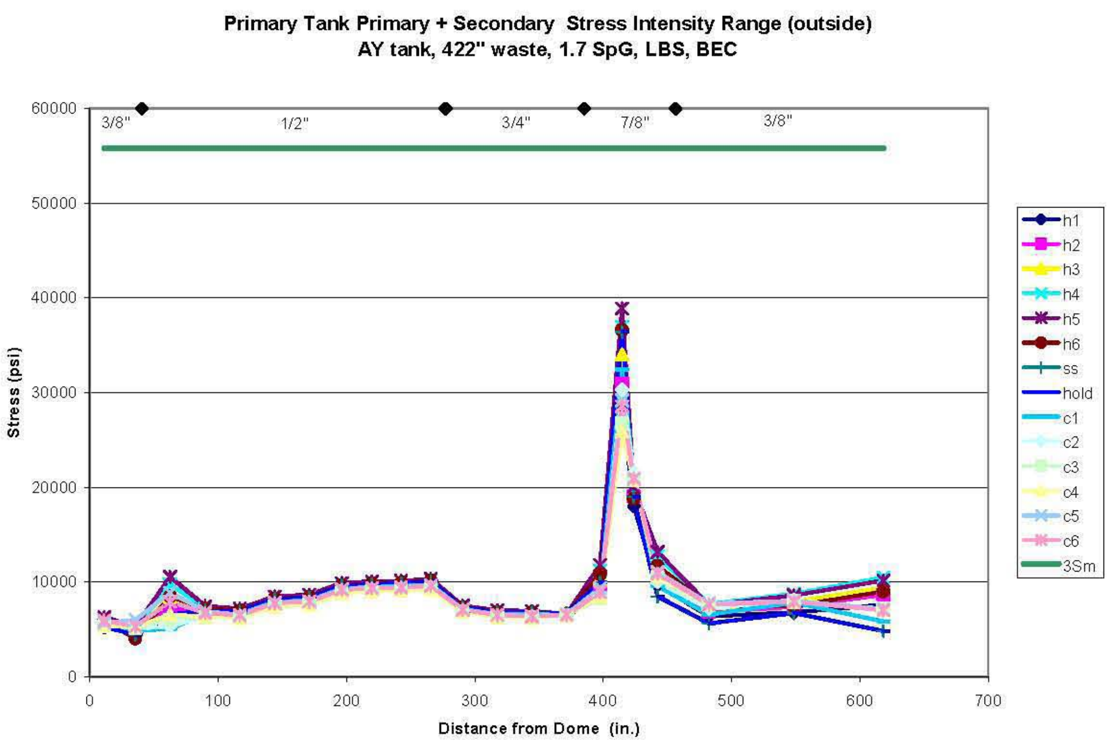

Figure 6-38. LBS – BEC Primary + Secondary (outside) Stress Intensity Range

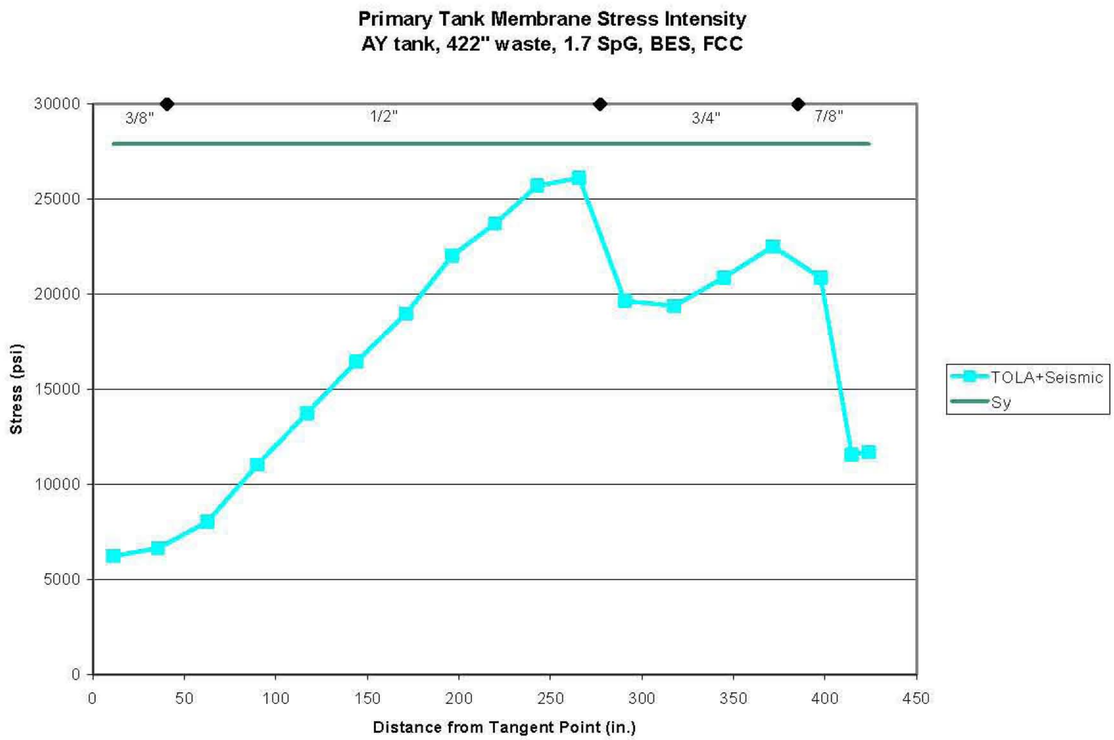

Figure 6-39. BES – FCC Primary Membrane Stress Intensity

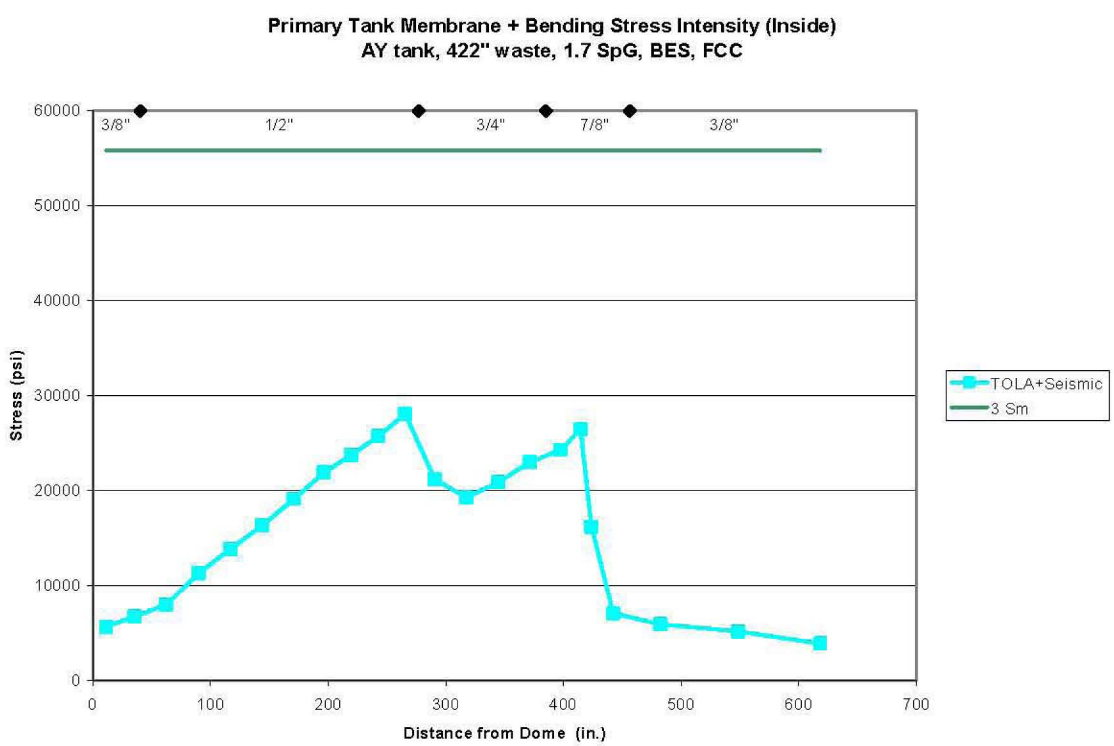

Figure 6-40. BES – FCC Primary Membrane + Bending (inside) Stress Intensity

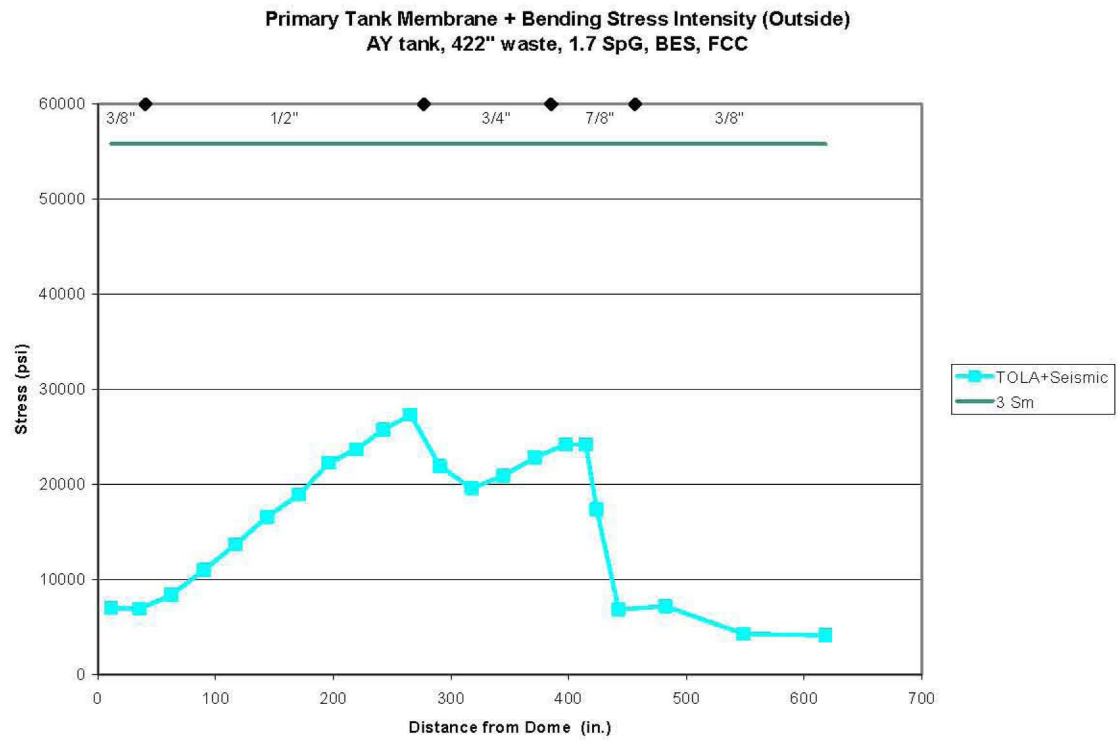

Figure 6-41. BES – FCC Primary Membrane + Bending (outside) Stress Intensity

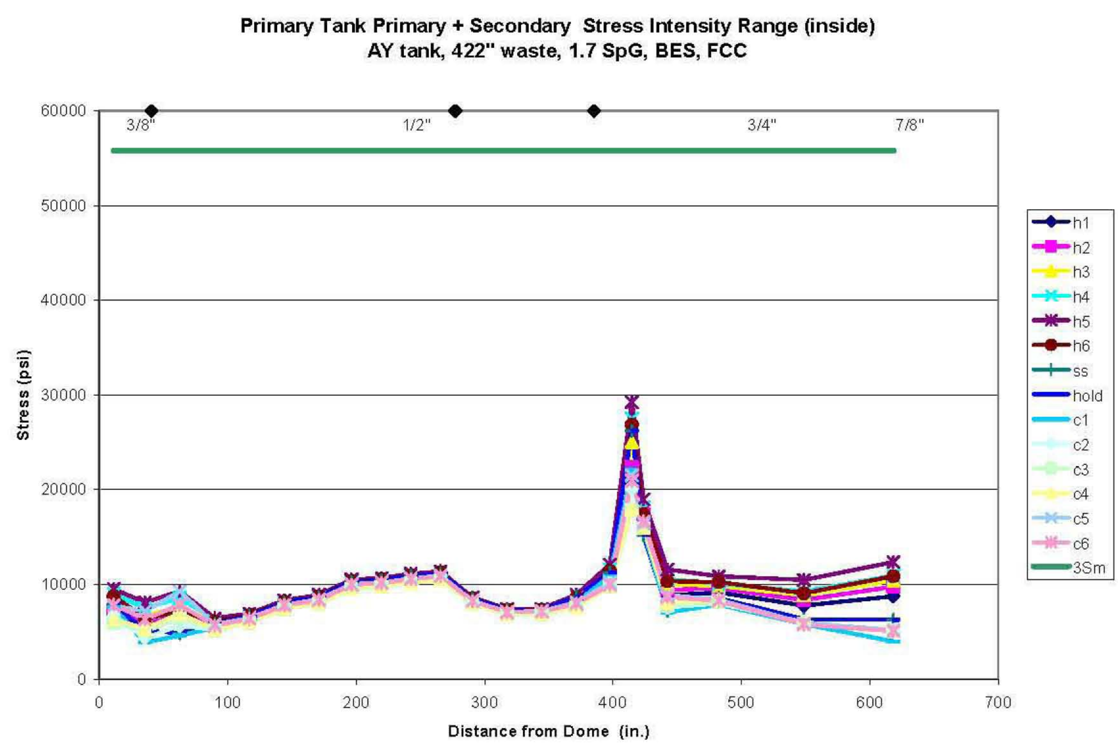

Figure 6-42. BES – FCC Primary + Secondary (inside) Stress Intensity Range

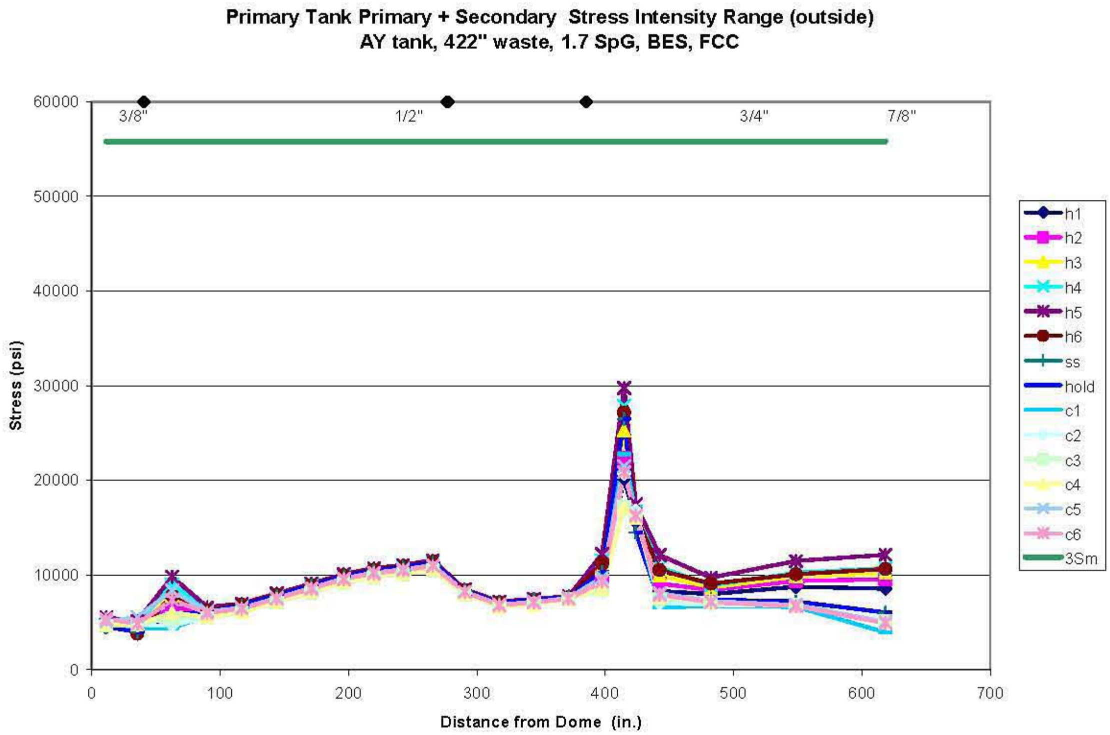

Figure 6-43. BES – FCC Primary + Secondary (outside) Stress Intensity Range

6.3 Primary Tank Stress Corrosion Cracking Evaluation

The Structural Acceptance Criteria document (Day et al. 1995) raises the issue of primary tank fracture by stress corrosion cracking (SCC) as a potential failure mode. However, the report does not set forth a criterion by which to assess the limits on stress, temperature, or waste chemistry to preclude such failure. The TOLA report (Rinker et al. 2004) used the previously postulated limit on the primary tank principal stress on the inner surface to 90% of the yield strength of the tank steel. Perhaps the earliest appearance of this criterion is the AP Tank Farm Functional Design Criteria (Garfield and Guenther 1981). Other indications are that the criterion was “less than yield” prior to construction of the AZ farm, but was changed to “90% of yield” beginning with the AZ tanks.

Intervening analyses, particularly the Expert Panel discussions regarding waste chemistry (Terry et al. 2004) raised concerns regarding the validity of this criterion. The subsequent evaluation of the stress criteria for stress corrosion cracking (Rinker et al. 2005) was unable to establish a technical basis for the 90% yield criterion. That report also observed that while other industries and other design codes are concerned about SCC, they do not address the issue solely on the basis of a stress limit. Other approaches to addressing SCC include reduction of tensile residual stress by post weld heat treatment (PWHT), control of environmental conditions (chemistry and temperature), in-service inspection to confirm the lack of stress corrosion cracks, and fracture mechanics calculations to assess the possibility of crack growth.

6.3.1 Analytical Evaluation

The SCC report (Rinker et al. 2005) developed a damage tolerance approach based on fracture mechanics methods as an alternative means of evaluation. That report focused specifically on Tank AN-107 because of the historical difficulty of maintaining the desired pH levels in the waste. The fracture mechanics calculations referenced crack growth rate data being developed concurrently (Brongers et al. 2005).

Earlier crack growth testing (Blackburn 1995a, b) in highly aggressive solutions has demonstrated relatively high crack growth rates. It was recognized, however, that these test conditions were very conservative in comparison to the lower temperatures and less aggressive chemical conditions of past and current tank operations. This conservatism was confirmed by the recent test results (Brongers et al. 2005) which showed no propensity to crack at equilibrium corrosion potentials, and one to two orders of magnitude lower crack growth rates with an induced voltage to bring the system into the SCC sensitivity range. Only insignificant crack growth was predicted over the projected life of tank operations. Accordingly, conservative values of K_{ISCC} were assigned to facilitate the fracture mechanics calculations.

Application of the fracture mechanics method to Tank AN-107 showed a very low potential for stress corrosion crack growth. There are, however, differences between the loads and tank geometry (wall thickness) of the AN-107 and bounding TOLA analysis described herein. The differences in load are summarized in Table 6-1.

Table 6-1. Comparison of TOLA and AN-107 Analyses

Feature	TOLA	AN-107
Soil overburden (ft.)	8.3	7.4
Overburden density (lb/ft^3)	125	120
Waste height (in.)	422	388
Waste specific gravity	1.70	1.43
Waste temperature (°F)	350	110

The effect of these differences on the lower knuckle inner surface principal stress is shown in Figure 6.45.

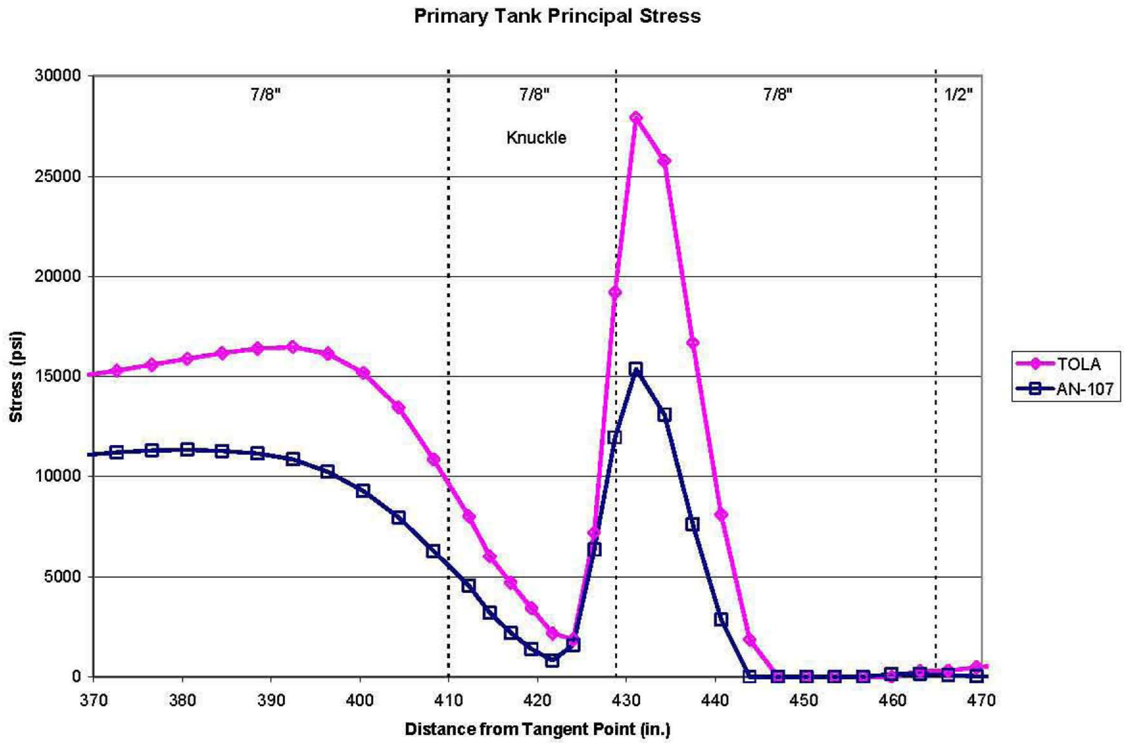

Figure 6-44. Comparison of TOLA and AN-107 Lower Knuckle Principal Stress

A parametric study on the effect of the applied bending stress to the sensitivity to crack growth was conducted as part of the SCC study (Rinker et al. 2005). Figure 5-5 from that report is reproduced here as Figure 6-46. Interpolation of the results to the TOLA bending stress of ±27 ksi suggest that crack growth is unlikely for an existing 0.10 inch crack unless K_{ISCC} is less than 21 ksi-in$^{1/2}$. These results are predicated on the assumption of the lower knuckle steel temperature being more moderate (≤ 150°F) than was historically recorded in the AY/AZ tanks.

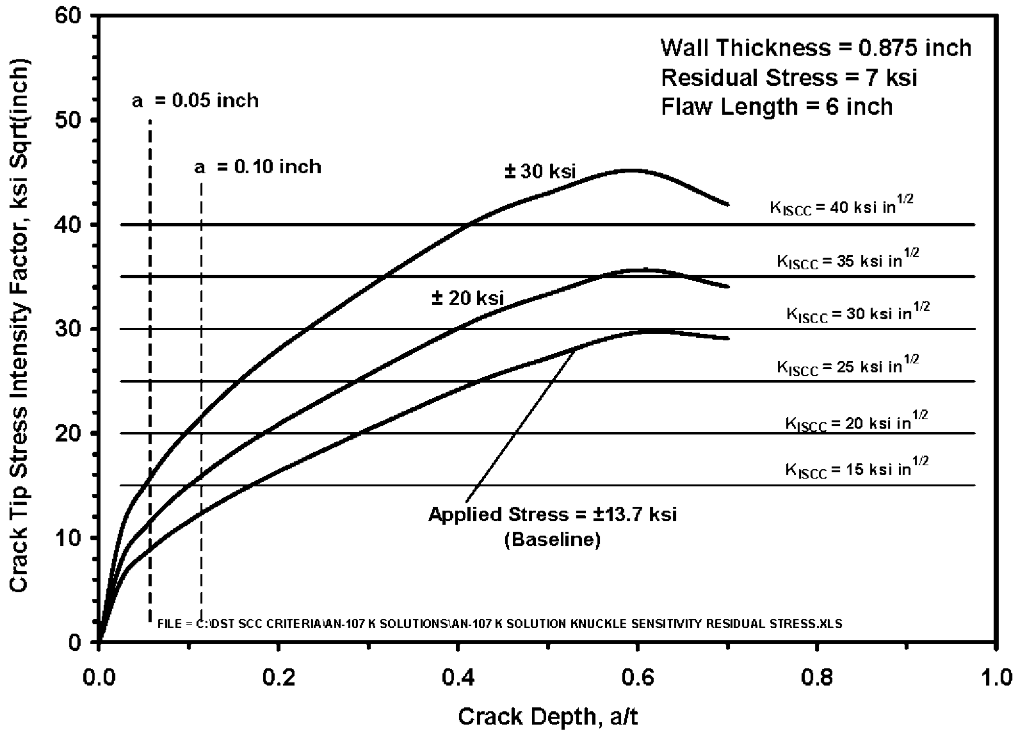

Figure 6-45. Effect of Applied Bending Stress on Calculated Stress Intensity Factor for the Lower Knuckle of Tank AN-107

6.3.2 DST Operating Experience

Appendix C of the SCC report (Rinker et al. 2005) summarized the operating experience with DSTs at both the Hanford Site and the Savannah River Site (SRS). Stress corrosion cracking occurred with some early waste tank designs, without PWHT, at Savannah River. These tanks were constructed of carbon steel but, unlike the Hanford DSTs, were not given post-weld heat treatments to reduce welding residual stresses. The SRS tanks with confirmed SCC were exposed to relatively high-temperature wastes with adverse waste chemistries that were outside the current limits imposed on both Savannah River and Hanford tanks. Other early Savannah River tanks (also of low carbon steels and without PWHT) were operated at less severe waste chemistries and temperatures without reported SCC.

Savannah River initiated research programs in response to the early cracking incidents. Results of this research showed the benefits of PWHTs and improved specifications for waste chemistry. Implementation of these mitigative measures has evidently been effective because there has been no further SCC either in the older tanks (without PWHT) or in newer tanks that used PWHT.

Hanford waste storage tanks have experienced leaks from the older single-shell tanks (no PWHT) but also achieved a record of no leakage from the newer DSTs with PWHT. It is not possible to examine failed liners of single-shell tanks which precludes the detailed analyses needed to determine whether the failures were caused by corrosion, wall thinning, pitting, or cracking. It is likely that SCC was a factor because none of the older tanks were given PWHT to reduce welding residual stresses. Furthermore, the past service conditions included storage of wastes at high temperatures with chemical compositions known to contribute to SCC.

In contrast, no SCC has been observed in any of the 28 Hanford DSTs over periods of operation that date back to 1971. Detection methods include observation of leakage from through-wall cracks, visual inspections of the outer surface of the tanks, and monitoring for moisture and the increased radiation levels caused by leakage from the primary tank into the outer annulus. Ultrasonic (UT) examinations have been used to look for cracks with less than through-wall depths (present sensitivity can detect very small defects but can only dimension them to 0.050 inch depth), and none have been detected in the lower knuckle region. These crack inspections are done on a 30 inch wide top-to-bottom vertical pass (~40 feet), as well as a 20 foot long segment of the lower knuckle region. However, these UT examinations have covered only a fraction of the tank wall, and depend on the covered fractions being representative of entire tank conditions. Uncertainties aside, it can nevertheless be concluded that the Hanford DSTs appear to have experienced no significant SCC degradation.

There has been no stress corrosion cracking observed in the Hanford DSTs under the present chemistry controls and operating parameters. Recent testing and analysis, and the historical operational record dating back to 1971, shows that SCC is unlikely if the present operating requirements are maintained. Temperature limits are lower and waste chemistry is much less aggressive than those that have caused cracking incidents in laboratory experiments and SRS waste storage tanks. If the chemistry controls are to be modified, as was done for AN-107, it is recommended that tank specific stress analysis and fracture evaluation be conducted in conjunction with SCC testing at the relevant conditions.

6.3.3 Seismic Considerations

Implicit in the definition of stress corrosion cracking is the presence of a static tensile stress. A seismic event is also by definition a transient event, lasting a much shorter duration than that required to produce SCC. However, it has been posited that seismically induced stresses, when added to the baseline stresses from the thermal and operating loads, may exceed the yield strength of the primary tank steel. Consequently, the stress state following the earthquake may be higher thus possibly promoting the development of SCC.

A simplified stress analysis of the lower knuckle was conducted to evaluate this scenario. A model of the lower knuckle was loaded with a downward displacement of the wall sufficient to achieve an inside surface stress just below the yield strength (32 ksi) of the steel. The displacement was then increased in a linear elastic analysis to give an additional 10 ksi stress. The analysis was then repeated with a nonlinear elastic-plastic stress-strain curve in place for the steel and the displacement then reduced back to the original level (near yield). The maximum inside surface stress decreased by nearly 5 ksi following this overstress event.

This analysis demonstrates that yielding of the lower knuckle due to increased meridional compression such as might result from an earthquake does not increase the inside surface stress after the transient event has passed. The model predicts that such an overstress condition may actually decrease the subsequent surface stress due to the load reversal effect in going from the over stress state back to the normal operating condition.

6.4 Primary Tank Buckling Evaluation

Buckling of the primary tank was considered in Section 8.5 of the TOLA report (Rinker et al. 2004). The evaluation method was based on the method defined in Code Case N-284-1 of the ASME B&PV Code, Section III, Division 1, (ASME 1995b). The buckling evaluation for service level D was conducted using seismic demands from the original design calculations (Blume and Associates 1974). A separate task of the *DST Integrity Project* was to conduct detailed buckling analyses, in part to "develop an approximate influence function to estimate the effect of changes between the finite element analysis parameters and the tank specific conditions." Accordingly, a new finite element model was developed, distinct from the TOLA model, and buckling evaluations were performed incorporating the results from the current seismic analysis (Carpenter et al. 2006). Complete documentation of the buckling evaluation is found in the Buckling Analysis report (Johnson et al. 2006).

6.4.1 Evaluation Method

Large displacement finite element analyses were used to predict the limiting vacuum load for the DST primary tanks under combined axial and vacuum loads. Figure 6-47 shows the model of the primary tank used in this analysis. A downward deflection was applied to the dome of the tank (the area in contact with the concrete tank structure) to simulate the displacement controlled axial compression of the tank wall that occurs due to concrete thermal degradation and creep, plus the confined thermal expansion of the steel tank inside the concrete shell. The model includes a geometric imperfection to initiate the buckling instability under the radially symmetric vacuum load. The imperfection was sized to the maximum out of roundness (1-inch deviation in a 7-foot arc length) allowed in the AY tank farm construction specifications (HWS-7789 Hanford Engineering Services 1968). Additional loads on the model include gravity and hydrostatic pressure of the waste at height, h, and specific gravity, SpG (see Figure 6-48).

The onset of the buckling instability was predicted by applying an increasing vacuum load on the inside surface of the tank while monitoring the maximum radial displacement of the tank wall as a function of the increasing vacuum load. The onset of instability is signaled by an increasing rate of radial deflection for a constant increment in the applied vacuum load. Figure 6-49 shows an example load deflection curve from one of the cases that were analyzed. Because vacuum is a primary load, the stresses are not self limiting and the model eventually fails to converge (numerically) as the physical load carrying capacity of the tank is reached. However, using the final converged vacuum load as the buckling limit is not a reliable measure of the onset of instability because the final convergence is sensitive to non-physical factors including the load step size, the convergence tolerance, and the numerical precision of the computer. Therefore, the ASME code was reviewed to find an appropriate method for defining the limiting vacuum load.

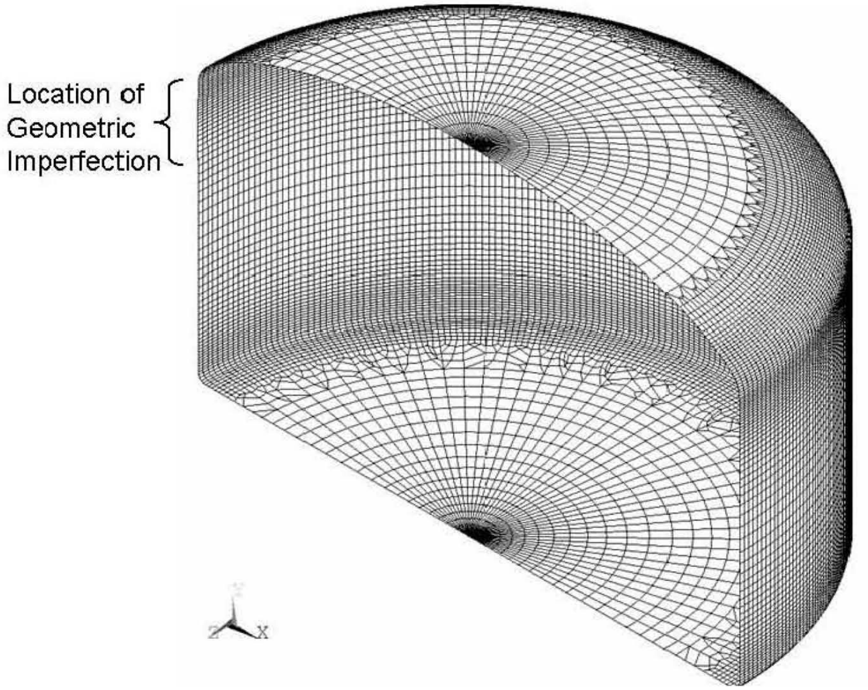

Figure 6-46. Buckling Model

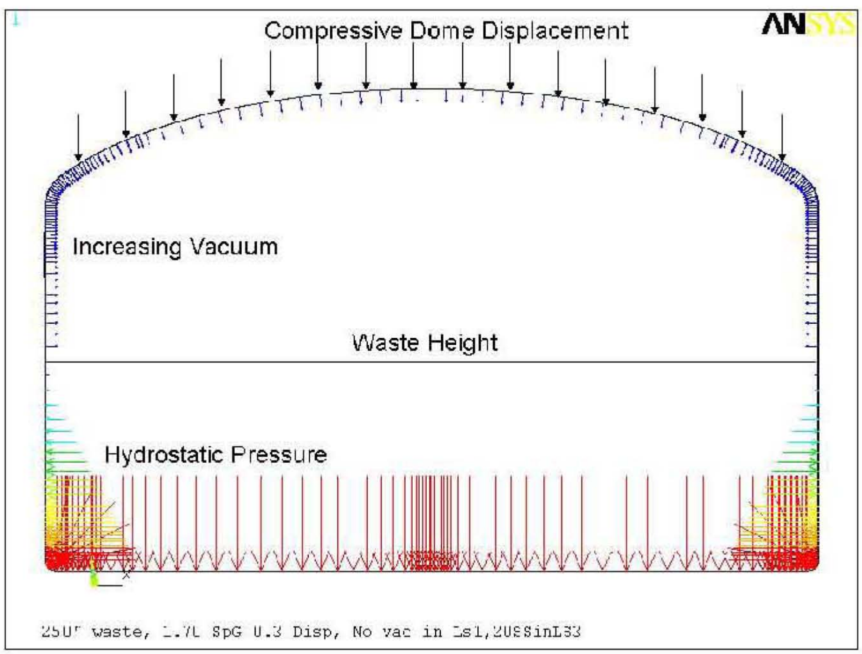

Figure 6-47. Buckling Model Loads

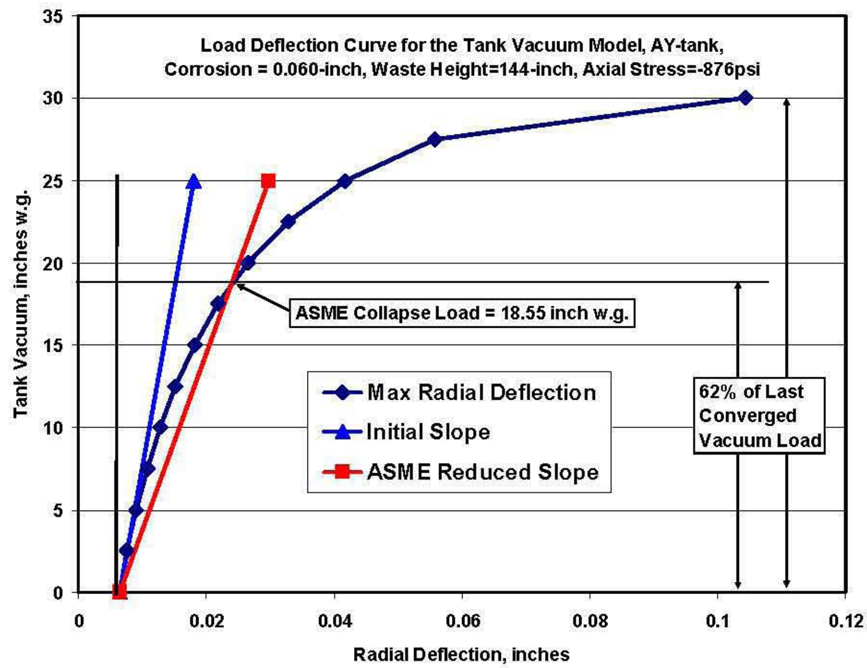

Figure 6-48. Buckling Load Deflection Curve

The ASME Boiler and Pressure Vessel Code, Section III, NB-3213.25 provides guidance on establishing a reasonable collapse load for a structure undergoing controlled plastic deformation (ASME 1995b). Although an elastic buckling phenomenon is being evaluating (the buckling models predict that the tank membrane stresses are well below the elastic limit), the increasing rate of distortion in the tank wall (for a constant increasing vacuum load) represents a gradual decrease in structural stiffness that is similar to a structure undergoing progressive plastic deformation. In the former case the stiffness reduction is due to the large deformations of the tank geometry that progressively decrease the load carrying capacity of the tank. In the latter case it is due to plastic softening. The ASME code method establishes the collapse load by limiting the reduction in structural stiffness under increasing load.

> ***NB-3213.25 Plastic Analysis — Collapse Load.*** *A plastic analysis may be used to determine the collapse load for a given combination of loads on a given structure. The following criterion for determination of the collapse load shall be used. A load–deflection or load–strain curve is plotted with load as the ordinate and deflection or strain as the abscissa. The angle that the linear part of the load–deflection or load–strain curve makes with the ordinate is called θ. A second straight line, hereafter called the collapse limit line, is drawn through the origin so that it makes an angle of $\tan^{-1}(2 \tan \theta)$ with the ordinate. The collapse load is the load at the intersection of the load–deflection or load–strain curve and the collapse limit line. If this method is used, particular care should be given to ensure that the strains or deflections that are used are indicative of the load carrying capacity of the structure.*

Figure 6-49 graphically illustrates the ASME code method based on the factor of two stiffness reduction. The radial displacement is offset from zero (at zero vacuum) because the initial loads (axial compression, hydrostatic pressure, and gravity) cause an initial radial deflection in the tank wall. The initial load/deflection slope was calculated and a second line was drawn at an angle with twice the tangent measured from the vertical axis. The vacuum limit was then calculated by interpolating to find the vacuum load where the second line crossed the load/deflection curve (Figure 6-49). In this case, the ASME collapse load is about 62% of the last converged vacuum load. Figure 6-50 shows the displaced shape of the tank model at the ASME collapse load. The displacements are magnified by a factor of 50 for visual effect. For the tank geometry, the ASME method results in a minor amount of tank distortion.

A matrix of tank models was run to develop equations for the tank vacuum limit as a function of waste height, specific gravity, wall thickness, and axial compressive load. Influence functions were developed to estimate the applied axial force in the primary tank wall which is required for evaluating buckling of the primary tank. The axial force contributions from the applied loads were evaluated, giving the total axial force as the sum of the following loads:

- Differential thermal expansion,
- Gravity,
- Surface loads,
- Concrete thermal degradation and creep,
- Seismic excitation, and the
- Effect of hydrostatic waste pressure on the confined axial force.

Once the unfactored axial force and vacuum limits are calculated, then the safety factors for the ASME Section III service levels are applied to calculate the allowable tank vacuum limits.

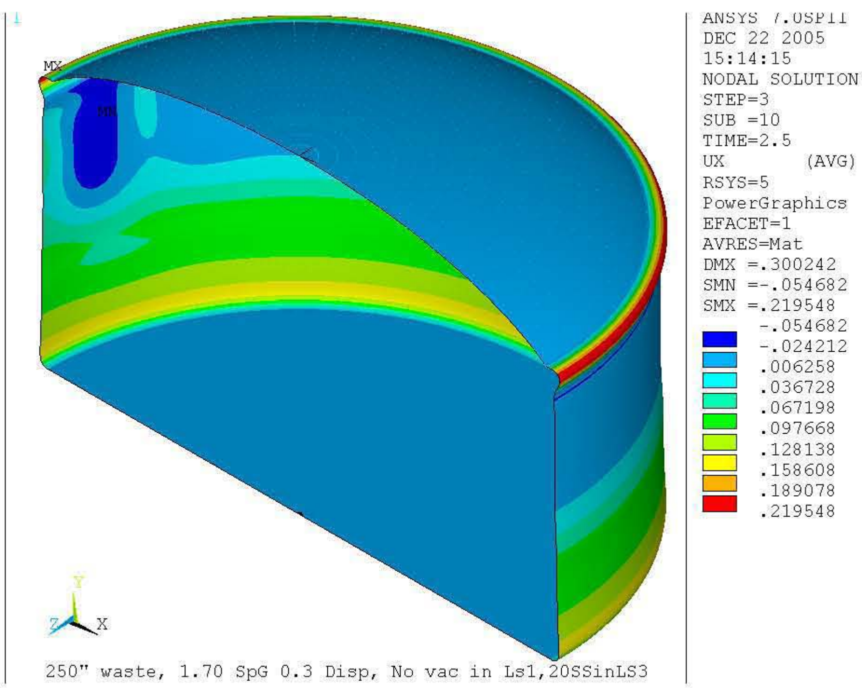

Figure 6-49. Model Displaced Shape at Vacuum Limit

6.4.2 Evaluation Criteria

The buckling calculations are conducted for the four different service levels defined in ASME Section III, each with required factors of safety for local and global buckling:

	Factors of Safety	
	Local Buckling	Global Buckling
Level A = Normal operating conditions	2.0	2.4
Level B = Upset conditions	2.0	2.4
Level C = Emergency conditions	1.67	2.0
Level D = Faulted conditions	1.34	1.61

Attachment B of Julyk (2002) makes the argument that axial compression in the tank cylinder will be relieved by local bowing of the wall before the onset of general instability. This position is justified since the meridional (axial) compressive stresses are displacement controlled as a result of differential thermal expansion and concrete creep induced loads on the primary tank. The load deflection response of the large displacement finite element models using in the current buckling analysis confirm that the axial stress in the tank is self-limited by the deformation of the primary tank geometry. This rational leads to the following buckling criteria when combining the effects of axial and hoop loads on the allowable vacuum:

The allowable vacuum (net negative pressure) in the double shell tanks is controlled by the minimum of two cases,

A. <u>Local Buckling</u> (with *<u>local</u>* buckling safety factors imposed) evaluated considering the interaction of the net internal vacuum load (Δp) combined with the meridional compressive stress (σ_ϕ).

B. <u>General Instability</u> (with *<u>global</u>* buckling safety factors imposed) evaluated considering the net internal vacuum load (Δp) acting alone. No interaction with the meridional compressive stress shall be considered ($\sigma_\phi = 0$).

These criteria were used by Julyk (2002) are they also used in the current buckling evaluation.

Julyk (2002) states that activation of the tank relief valves at the limiting vacuum load should be classified as a Level C (emergency) load condition. This is justified because the normal vacuum imposed by the tank ventilation systems is about 3 inches w.g. compared to the vacuum limit of 6.6 inches w.g. for the AY, SY, AN, AW, and AZ tanks and 12 inches w.g for the AP primary tank. The relief valves (set at the limit values) are not expected to activate over the operating life of the tanks and at worst this would occur no more than 25 times. Therefore, activation of the relief valves would be an off-normal occurrence, which is consistent with the ASME Service Load Classification for Level C events.

It is assumed in this analysis that the design basis loads used in the thermal and operating loads analysis conservatively represent Service Levels A, B, and C. This is consistent with the loading conditions assumed by Julyk (2002). Service Level D, however, requires that the incremental seismic stresses be added to the design basis stresses for evaluating the faulted condition.

6.4.3 Buckling Results

An Excel™ spreadsheet was constructed using the relationships documented in detail in the Buckling report (Rinker et al. 2006) and applies the Section III service level safety factors to calculate the vacuum allowables for the primary tanks. Table 6-2 shows a summary of the allowable vacuum calculations that are based on the current operating limits for waste temperature, waste height, and waste specific gravity. A corrosion allowance of 0.060 inch was assumed in these calculations. Table 6-2 shows that the calculated allowable vacuum limits are greater than the current vacuum allowable for all of the tanks except the AP tanks. The current AP vacuum allowable is 12 inches w.g. compared to the calculated allowable of 10.53 inch w.g.

Additional analyses of the AP Tank showed that the allowable vacuum was above the 12-inch limit for corrosion allowances less than 0.025 inch. Little or no corrosion has been observed in the primary tanks (Jensen 2003 and 2005) such that this wall thickness is appropriate for the buckling calculation. With this assumption, all the tanks pass the buckling criteria.

6.5 ASME Concrete-Backed Steel Evaluation

The evaluation criteria for the concrete-backed steel liner (both primary and secondary liner) are specified by Day et al. (1995) in WHC-SD-WM-DGS-003. These requirements were taken from the ASME B & PV Code, Section III, Division 2, Subsection NC-3700 (ASME 1992c). The seismic load component is added to the factored load combination under the abnormal/extreme environmental category.

6.5.1 Best Estimate Soil – Best Estimate Concrete

The principal membrane strain evaluation is shown in Figures 6-51 and 6-52 for the tension and compression components, respectively. Figures 6-53 through 6-56 show the membrane plus bending strain evaluation at the inner and outer surfaces. All the concrete-backed liner strains are well below the allowable levels.

Table 6-2. Summary of Primary Tank Buckling Evaluation

	DST Primary Tanks					
	AY	AZ	SY	AW	AN	AP
Approx. Operating History						
Temp, F	250	250	150	150	150	120
Hwaste, inch	370	370	422	422	422	422
Operating Limits						
Temp, F	350	350	250	350	350	210
Hwaste, inch	370	370	422	422	422	422
SpG	1.77	1.77	1.70	1.70	1.70	2.00
Corrosion Allowance, inch	0.060	0.060	0.060	0.060	0.060	0.060
Yield at Temp, ksi	27.85	27.85	31.45	39	39	39.7
Calculated Axial Forces						
Operating Axial Force, kip/inch	-0.696	-0.696	-0.413	-0.590	-0.590	-0.349
Oper+Seismic Force, kip/inch	-1.073	-1.073	-0.784	-0.958	-0.958	-0.875
Axial Force Limit, kip/inch	-1.308	-1.308	-1.477	-1.719	-1.719	-2.842
Calculated AllowableVacuum Limits, inches w.g.						
Local Buckling						
Service Level A&B	7.55	7.55	8.32	7.78	7.78	9.70
Service Level C	9.04	9.04	9.96	9.32	9.32	11.62
Service Level D	9.04	9.04	10.60	9.56	9.56	13.48
Global Buckling						
Service Level A&B	7.91	7.91	7.88	7.88	7.88	8.78
Service Level C	9.49	9.49	9.45	9.45	9.45	10.53
Governing Allowable Vacuum, inch w.g.	7.55	7.55	7.88	7.78	7.78	8.78
Governing Allowable when vacuum = Level C load	9.04	9.04	9.45	9.32	9.32	10.53
Current Vacuum Limit, inches w.g.	6	6	6	6	6	12

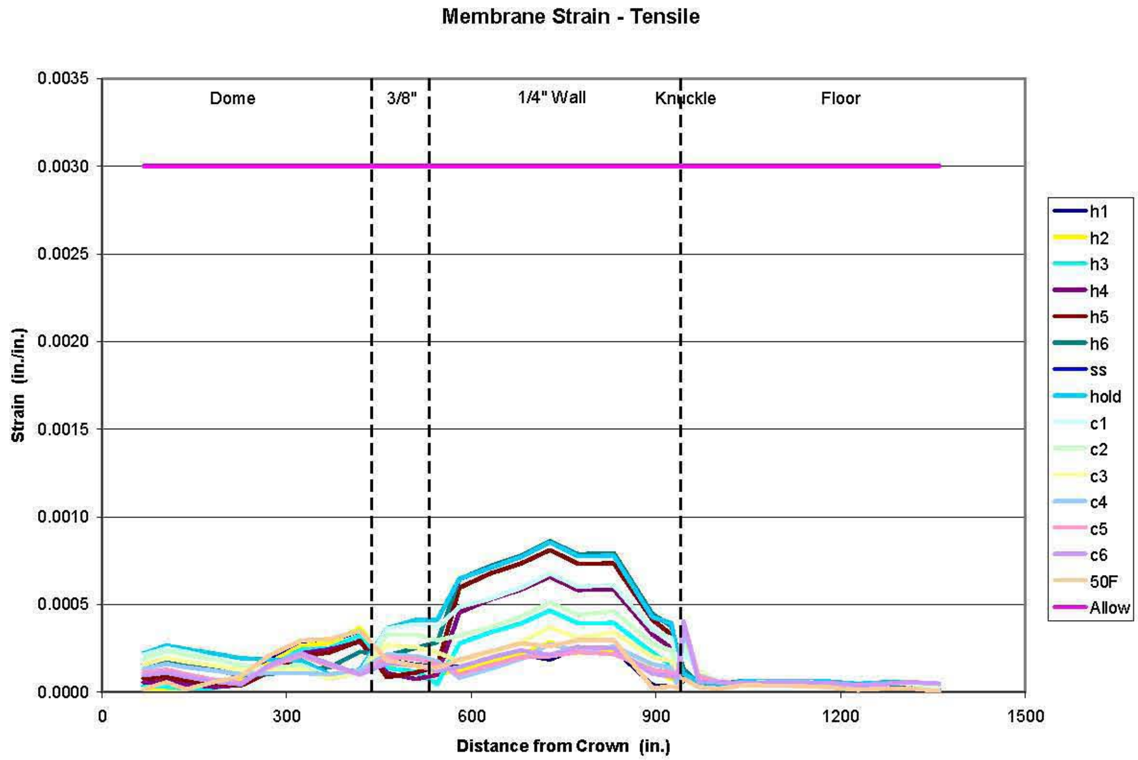

Figure 6-50. BES – BEC, Principal Membrane Strain – Tension (ε_1)

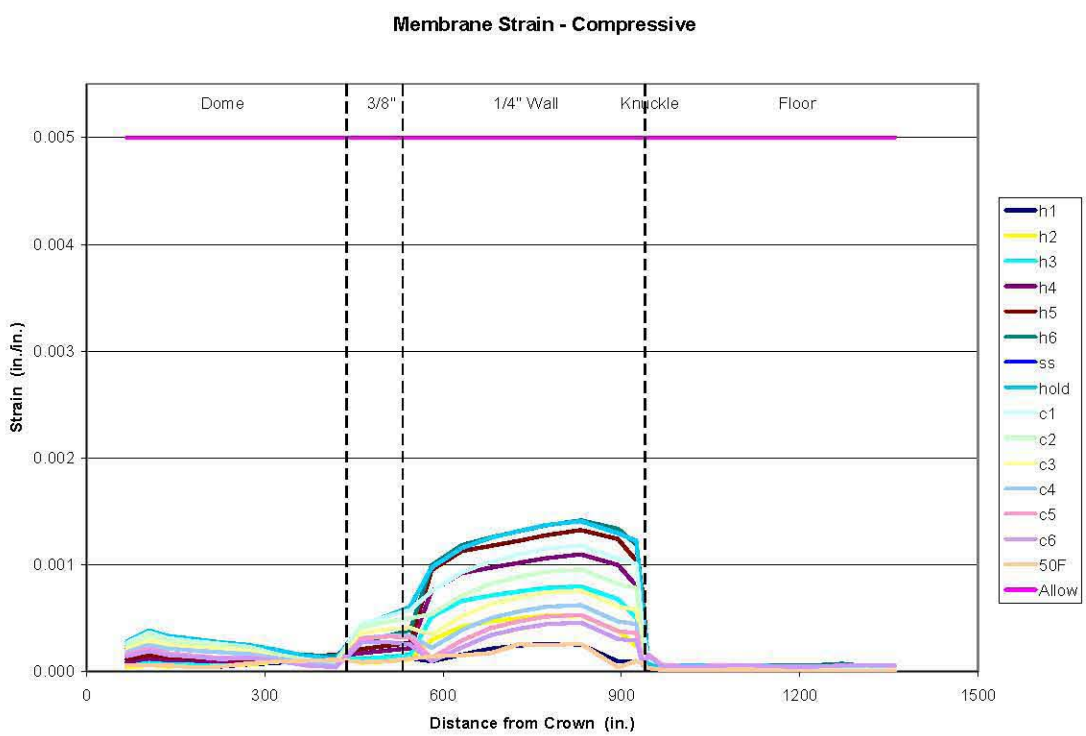

Figure 6-51. BES – BEC, Principal Membrane Strain – Compression (ε_3)

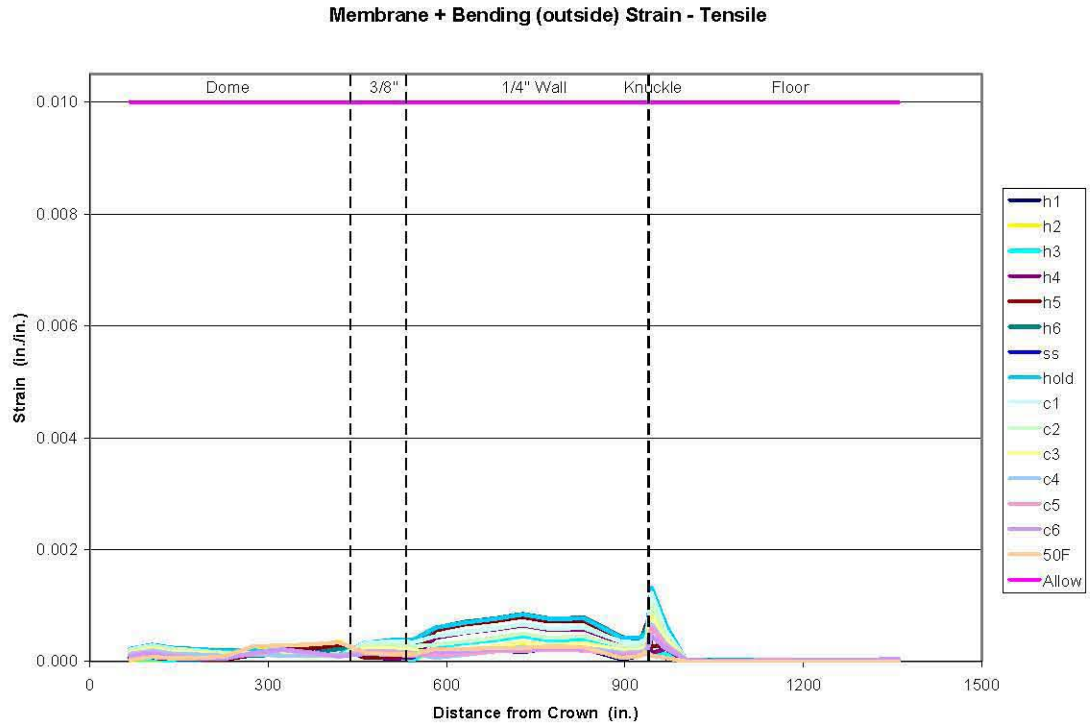

Figure 6-52. BES – BEC, Principal Membrane + Bending Strain Outer Surface – Tension (ε_1)

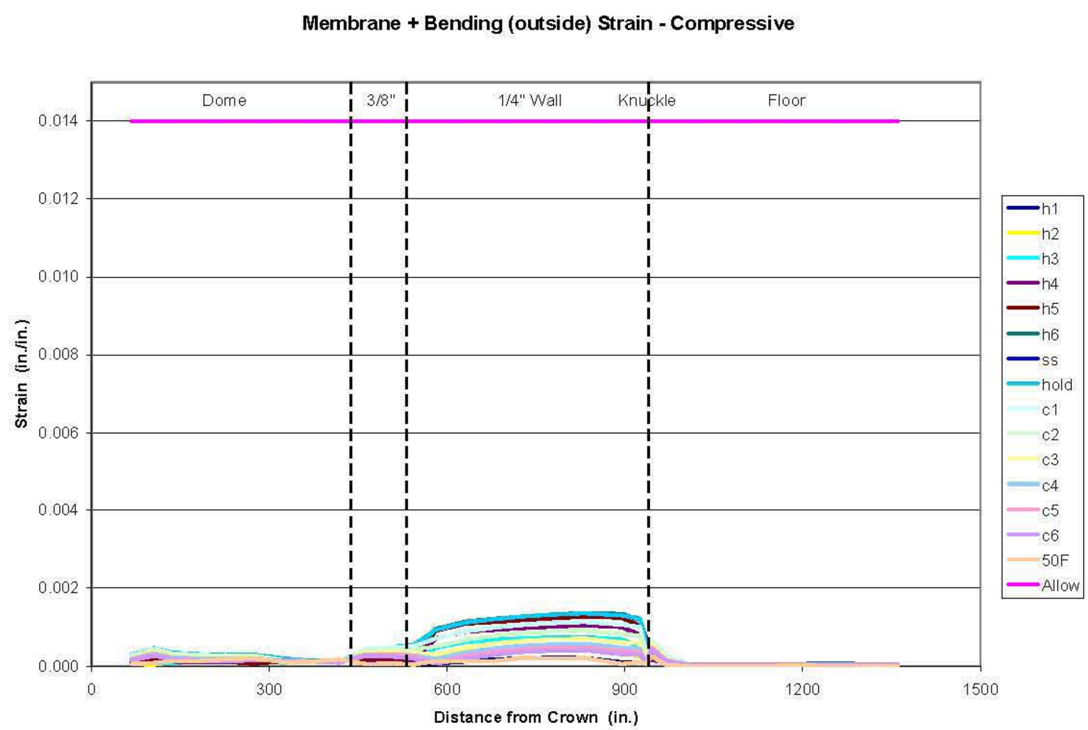

Figure 6-53. BES – BEC, Principal Membrane + Bending Strain Outer Surface – Compression (ε_3)

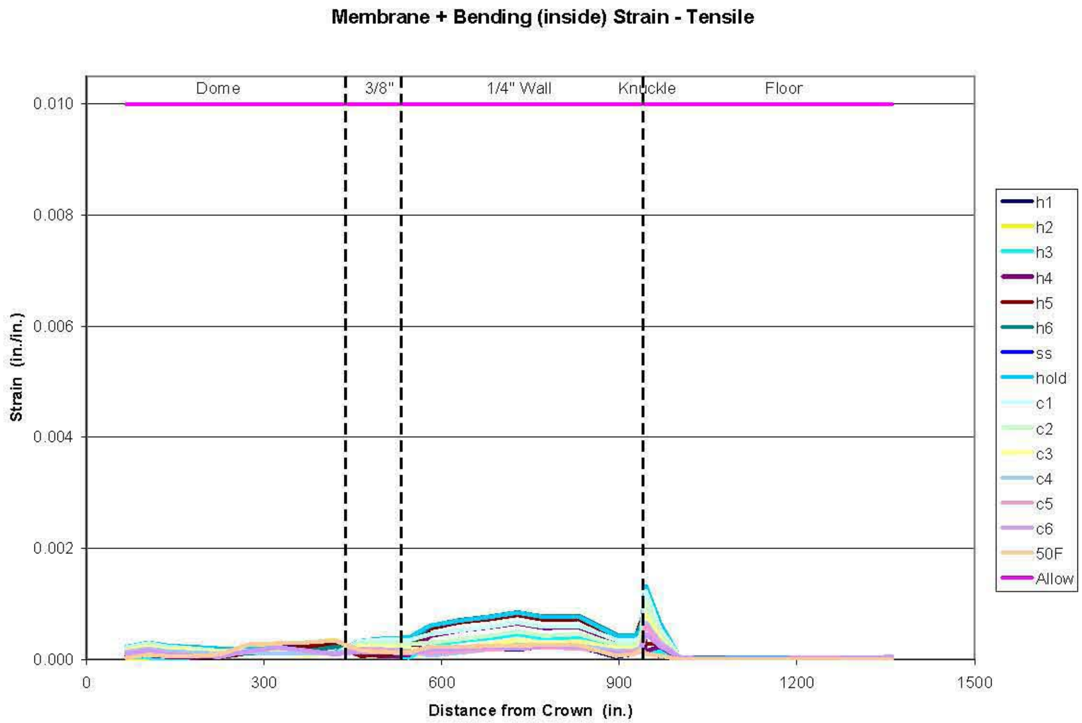

Figure 6-54. BES – BEC, Principal Membrane + Bending Strain Inner Surface – Tension (ε_1)

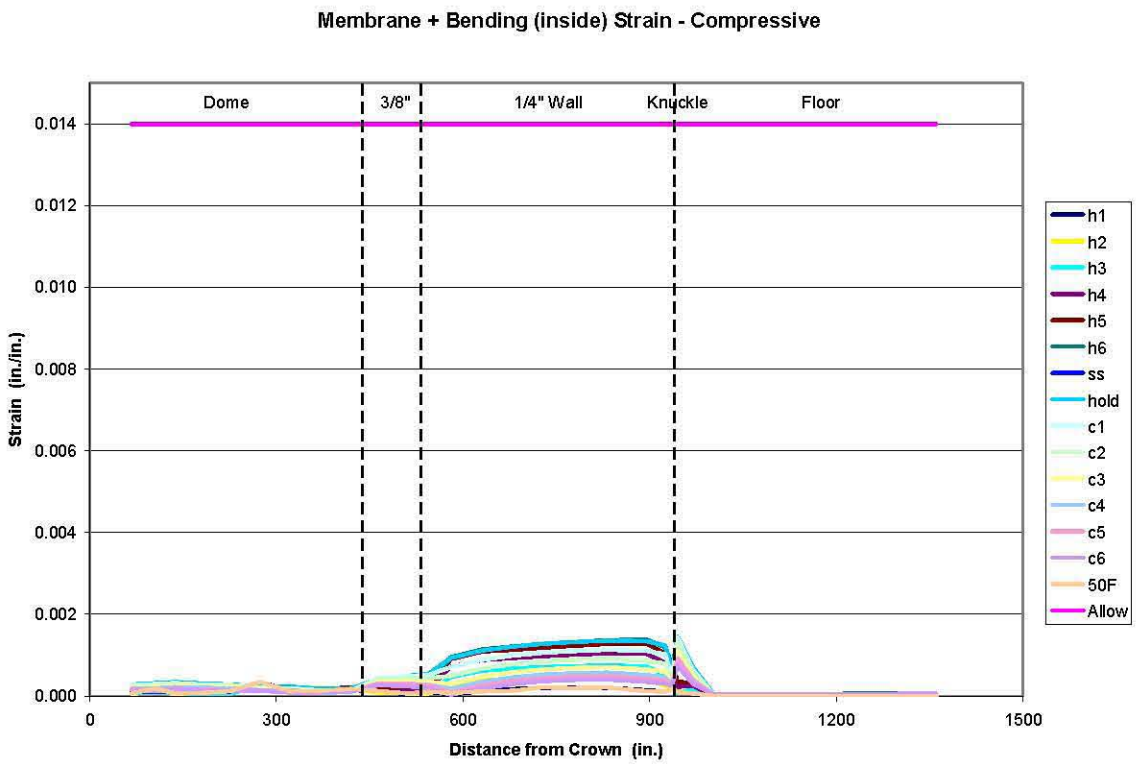

Figure 6-55. BES – BEC, Principal Membrane + Bending Strain Inner Surface – Compression (ε_3)

6.5.2 Other Soil and Concrete Combinations

Strain results from the seismic analyses of the other soil and concrete combinations were not available at the level of detail required for combination with the TOLA results. However, given the large margin illustrated in Figures 6-51 through 6-56 and the relatively little variation in strain with the different soil and concrete properties, it is reasonable to conclude that the concrete-backed liner for the other soil and concrete combinations also readily satisfies the ASME code allowable. Figures 6-57 and 6-57 demonstrate that there is little variation in the seismic and TOLA strain intensity.

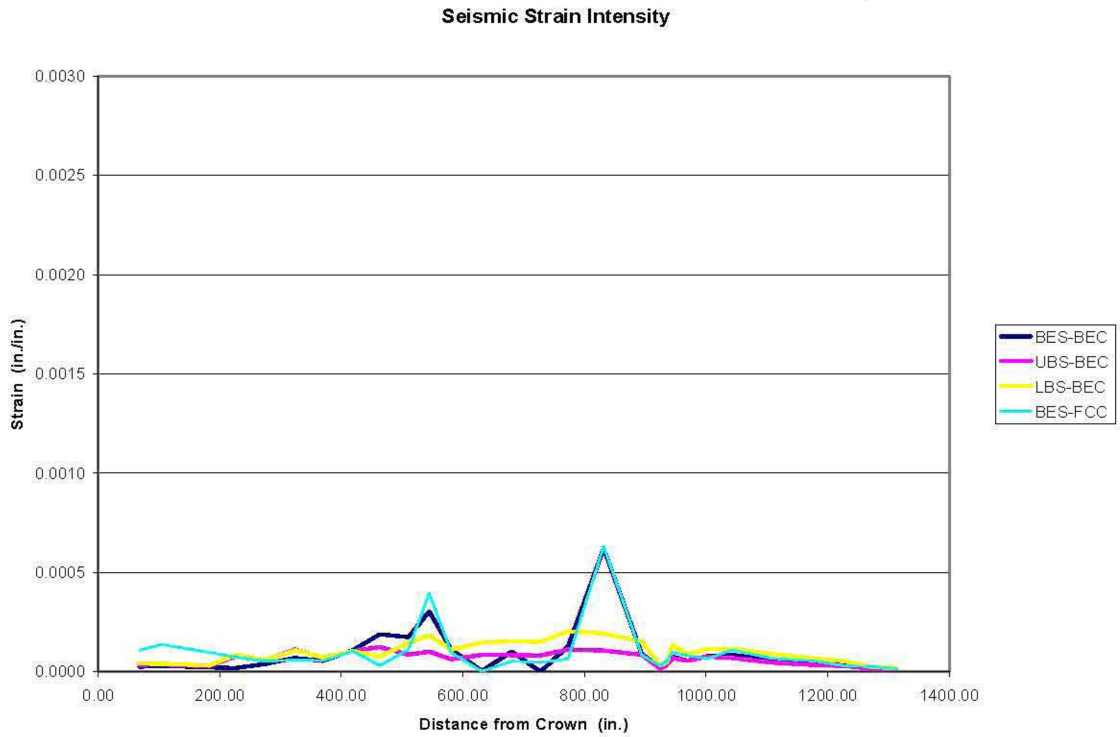

Figure 6-56. Seismic Strain Intensity

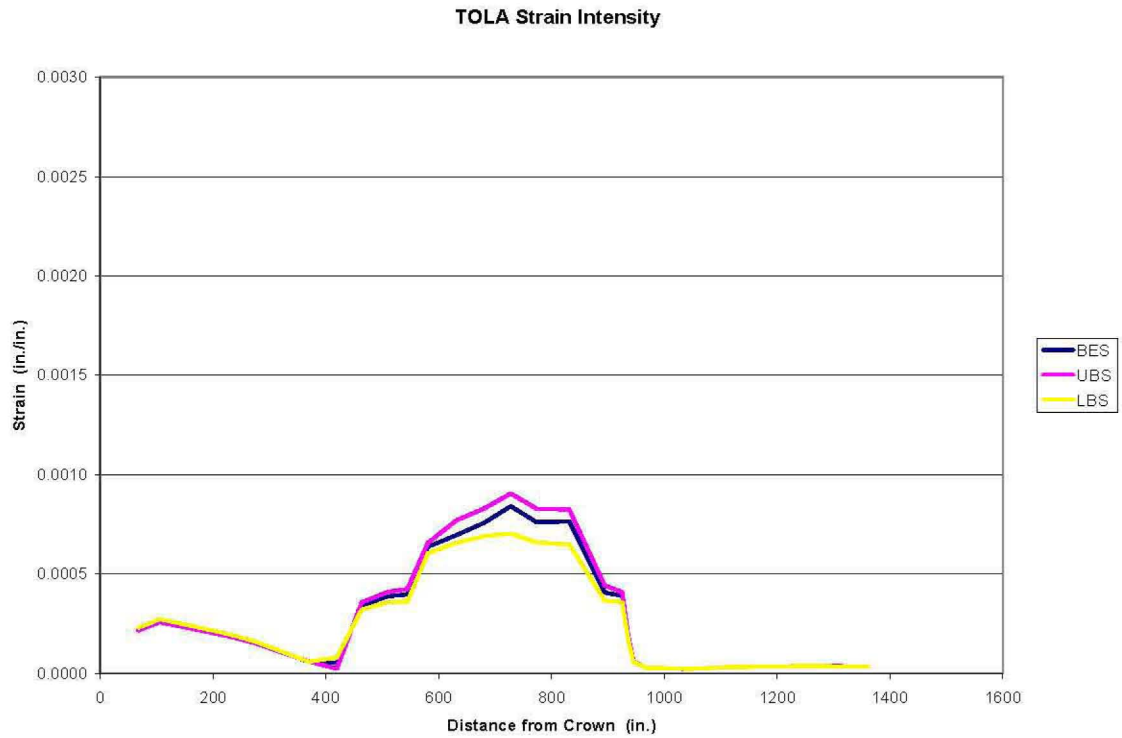

Figure 6-57. TOLA Strain Intensity

6.6 Anchor Bolt Evaluation

The modeling and evaluation of the primary tank dome anchor bolts changed in Rev. 1 of this report in response to reviewer comments. This evaluation is conducted in accordance with ACI 349-01 in contrast to the ASME Section III evaluation reported in Rev. 0. Complete details of the anchor bolt modeling and evaluation method are found in Appendix D.

The bulk of the analyses documented in this report (concrete, primary and secondary steel liner, etc.) were conducted with a maximum waste temperature of 350°F. The anchor bolt evaluations were conducted at a maximum waste temperature of 160°F. This temperature was derived in consultation with Tank Farms Operations personnel as providing an adequate margin to cover all forecast future DST operational limits. In addition, the dome temperature was limited to 135°F. The anchor bolt evaluations are shown in Figures 6-58 through 6-63.

The primary tank dome anchor bolt displacements are within the allowable limit for all combinations of soil and concrete.

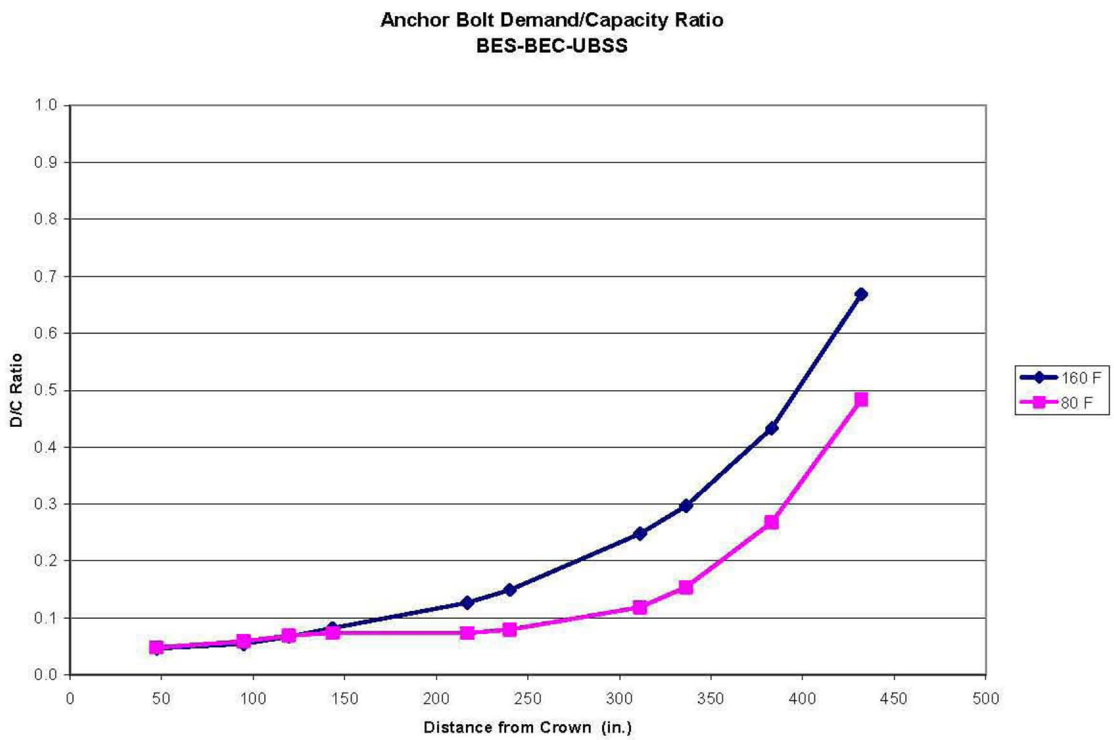

Figure 6-58. BES – BEC - UBSS, Anchor Bolt Evaluation

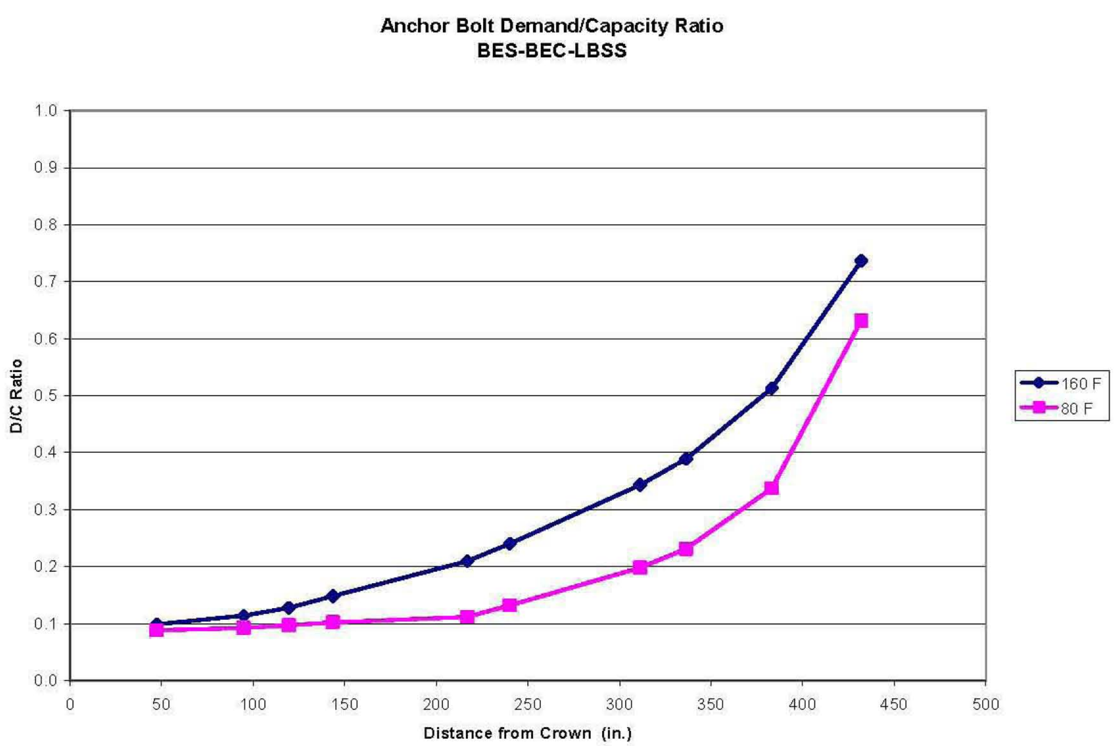

Figure 6-59. BES – BEC - LBSS, Anchor Bolt Evaluation

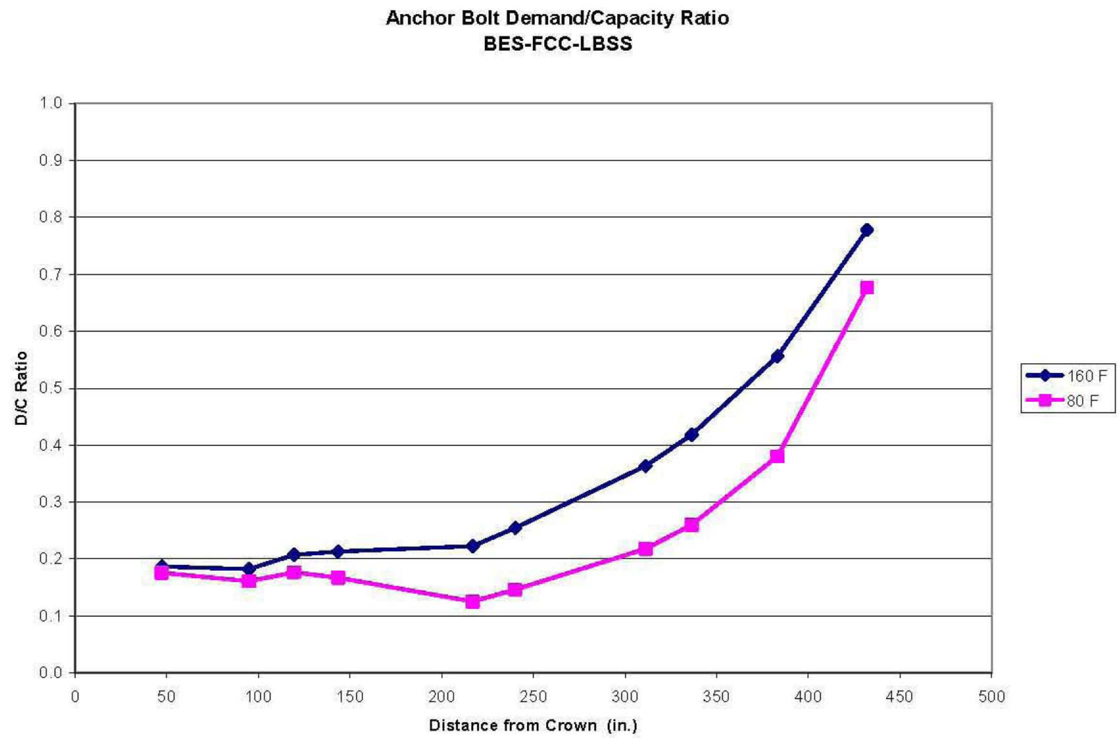

Figure 6-60. BES – FCC - LBSS, Anchor Bolt Evaluation

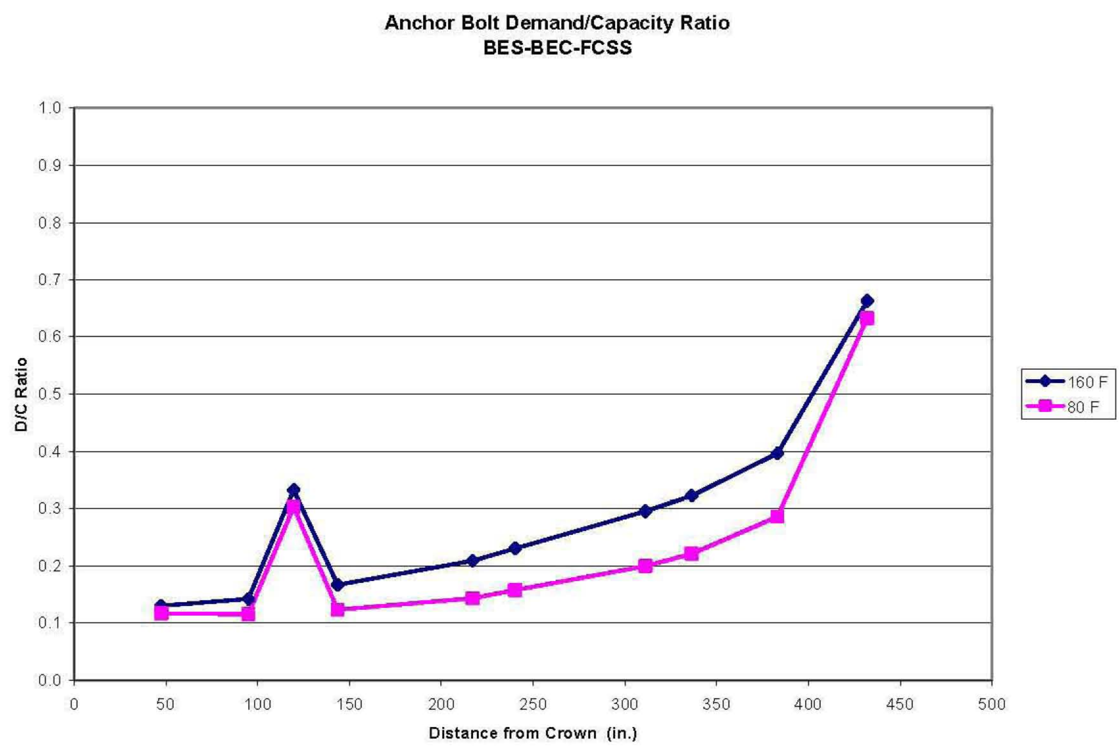

Figure 6-61. BES – BEC - FCSS, Anchor Bolt Evaluation

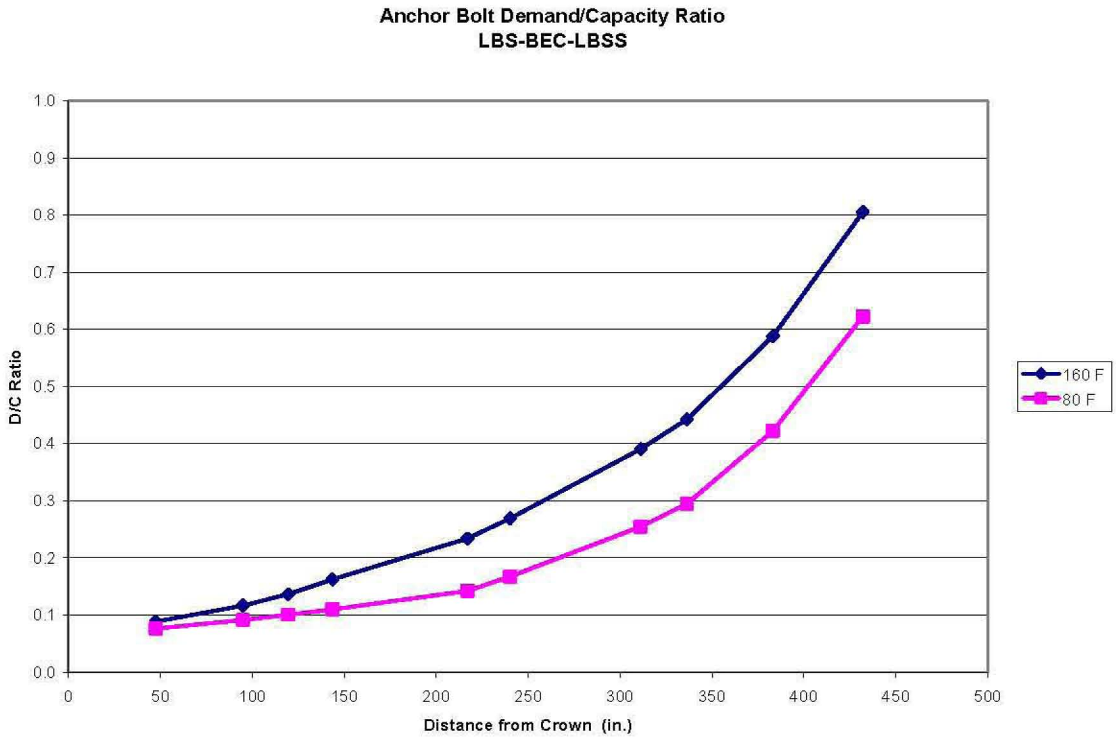

Figure 6-62. LBS – BEC - LBSS, Anchor Bolt Evaluation

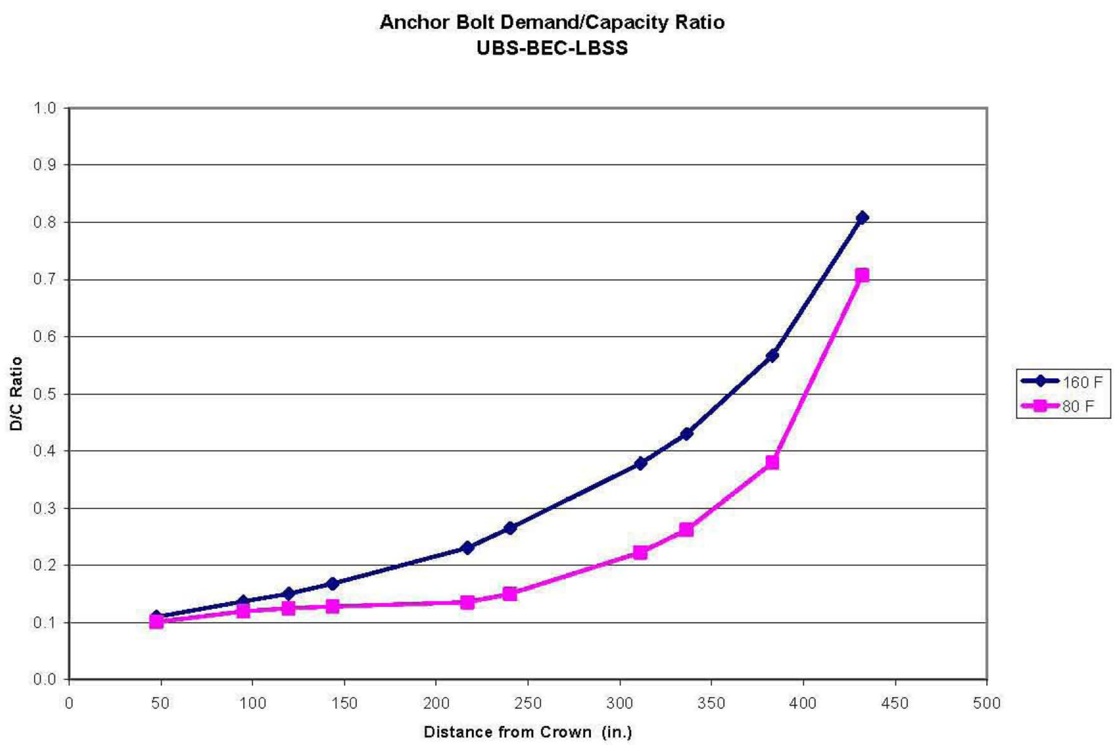

Figure 6-63. UBS – BEC - LBSS, Anchor Bolt Evaluation

7.0 Conclusions and Recommendations

The code evaluations reported in Chapter 6 for the representative tank model results do not reveal any structural deficiencies with the integrity of the double-shell tanks. The analyses represent 60 years of use, which corresponds to an additional 24 (AY) to 40 (AP) years of use beyond the current date. The loads imposed on the model for the finite element analyses are significantly more severe than any service to date or proposed for the future. The material properties were selected to be lower bound and in the most severe combinations.

7.1 Reinforced Concrete

The reinforced concrete structure was evaluated in the manner required by ACI-349. Load combination 4 of the ACI code, which includes the seismic load, was evaluated for each combination of soil and concrete properties. The axial load and moment were evaluated on the load- moment interaction diagram for each individual cross section. The demand was demonstrated to be lower than the capacity at all locations for all load combinations. The cross-section shear demand was less than the capacity for all sections. The in-plane shear demand/capacity ratios were evaluated for the seismic loads and showed low values.

7.2 Primary Tank

The primary tank is governed by ASME B & PV Code, Section III, Division 1. The allowable stress value, S_m, is provided by the code at operating temperature, which was assumed to be 350°F for operating loads. This value at this temperature was used for all the stress intensity code checks regardless of temperature. All sections of the primary tank were checked to Service Level D requirements with k = 2.0, but the general primary membrane stress intensity was subject to the additional constraint that it be limited by the lesser of kS_m and S_y. In all instances the unfactored primary membrane stress intensity remained below the yield stress (which is lower than the allowable $2S_m$).

Additionally, the primary local membrane plus bending stress intensity remained below the code allowable value of 1.5 kS_m, and the primary + secondary (thermal) stress intensity range remained below the code allowable value of 3.0 S_m. Therefore, the primary tank is acceptable according to the established criteria.

7.3 Stress Corrosion Cracking

The use of the criterion limiting the primary tank principal stress on the inside surface to 90% of the yield strength of the steel to prevent stress corrosion cracking was discontinued with this analysis. The SCC report (Rinker et al. 2005) discouraged further use of this criterion, citing the lack of a technical basis. The fracture mechanics method developed in that report was extended to evaluate the bounding tank under the thermal and operating loads. The results when considered with the current crack growth rate testing show that SCC is unlikely if the present operating requirements are maintained. If the chemistry controls are to be modified, as was done for AN-107, it is recommended that tank-specific stress analysis and fracture evaluation be conducted in conjunction with SCC testing at the relevant conditions. Analysis also showed that the propensity for SCC would not be increased after a seismic event.

7.4 Primary Tank Buckling

A large displacement finite element analysis method was developed to evaluate the potential for buckling of the primary tank. The method was shown to have good correlation with the ASME code case N-284 method. The primary tank buckling evaluation was carried out on a tank-specific basis because of the sensitivity of the analysis to waste height, specific gravity, tank wall thickness, and primary tank vapor space vacuum limit. The only tank of potential concern was the AP tank, which showed the current limit on demand of 12 inch w.g. vacuum to exceed the ASME allowable of 10.4 inch. This determination was based on analysis at the full 60-year corrosion allowance on the tank wall of 0.060 inch. However, analysis at a corrosion allowance of 0.025 inch results in an acceptable demand/capacity ratio. Therefore, the current limits on the maximum vacuum level of 6.6 inches w.g. for the AY, AZ, SY, AN, and AW tanks and 12 inches w.g. for the AP tanks are acceptable given the current lack of corrosion in the tanks.

7.5 Concrete-Backed Liner

The evaluation criteria for the secondary steel liner are strain-based and taken from the ASME B & PV Code, Section III, Division 2, Subsection NC for normal service loads. The results in all cases demonstrate that the secondary liner strains are all well below the allowable strain levels. Therefore, the secondary liner is judged to be adequate.

7.6 Anchor Bolts

Evaluation of the anchor bolts was based on the methods of ACI 349-01. The displacement-limited load evaluation was conducted at the specified waste temperature of 160°F. In all cases the anchor bolts were within the allowable range. Therefore, the anchor bolts are considered to be satisfactory.

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Appendix A

Seismic Model Primary Tank Knuckle Stress Evaluation

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Seismic Model Primary Tank Knuckle Stress Evaluation

A.1. Introduction and Purpose

The complexity of the global DST seismic model required that some mesh resolution be sacrificed in the lower knuckle region of the primary tank. The purpose of this appendix is to establish a factor that will be applied to the global seismic model lower knuckle stress components to account for loss of accuracy due to the limited mesh resolution (discretation error). This factor can be applied to the lower knuckle stress components from the global seismic model before combining the results with the TOLA model stresses and performing the primary tank ASME code evaluation. Although this Appendix focuses on the AY configuration, both AY and AP tank are addressed using a common methodology.

A.2. Background

A study of the effect of mesh resolution on the stresses in the lower knuckle of the primary tank in the seismic model was documented in Appendix A of Rinker et al. (2006). The important conclusions of that study were that increasing the mesh resolution in the lower knuckle from two elements to eight elements produced sufficiently accurate stresses, and that a single factor of 2.0 applied to the meridional and hoop stress components was more than enough to account for loss of mesh resolution in the global model.

Further investigation was motivated by a comment from reviewers R.P. Kennedy and A.S. Veletsos during a July 2007 project review meeting. The text of the comment appears below in italics.

> *The lower knuckle of the primary tank is too crudely modeled in the global analysis of the soil-structure-waste system to accurately define the peak values of the stresses induced in it. To provide for this inadequacy, the maximum values of the stresses determined in the global analysis for this region were increased by a factor of 2.0. We understand that this factor was based on the increase in maximum stresses determined for a refined model of the knuckle considering the effects of the hydrostatic pressures only.*
>
> *While this amplification factor may indeed be adequate for the hydrostatic effects, we are concerned that it may not be adequate for the seismically induced effects. As the seismic loading, unlike the hydrostatic, induces a substantive axial force in the tank-wall, we expect the increase of the bending stresses in the knuckle to be larger for the seismic loading than for the hydrostatic.*
>
> *We recommend that the stresses in the refined local model of the lower knuckle be determined using the maximum values of the boundary forces and of the associated pressures computed in the seismic analysis of the global model. A comparison of the*

absolute maximum values of the resulting stresses with those obtained by the global model would then provide a more defensible estimate of the amplification factor that should be applied to the seismically induced effects determined with the global model.

Alternatively – although this option is not as desirable – an approximate estimate of the requisite amplification factor may be determined by a static analysis similar to the one used, provided the vertical and circumferential distributions of the pressures considered are representative of those of the impulsive component of the seismically induced pressures.

Considering that some of the reported analyses indicate the absolute maximum stresses to occur in the base plate, slightly beyond the lower end of the knuckle, it is important that the local model does include this region.

The approach to the evaluation differs from that reported in Revision 0 of this Appendix in the following important aspects:

1. The focus of the evaluation is the differences in results between the global seismic model (with two elements in the knuckle) and the results the global seismic model *would have* if a more accurate eight element mesh had been used in the knuckle.
2. The axisymmetric study model used in Revision 0 was abandoned in favor of a slice model so that the global model and study model used the same element types. The slice study model is based directly on the global seismic model.
3. The adjustment factor is based on the differences in results between the slice study model with two elements in the knuckle vs. with eight elements in the knuckle. The previous approach compared the results from two different models: the global seismic model, and the TOLA model.
4. Because the slice study model is based directly on the global seismic model and uses the same element types, it was judged to be unnecessary to "benchmark" the study model against the thermal and operating loads analysis (TOLA) model. Thus, the TOLA model is no longer referenced in this evaluation.
5. Based on the results from Revision 0 and the mesh refinement in the thermal and operating loads analysis (TOLA) model, it was determined that having eight elements in the knuckle provides sufficient mesh refinement.
6. The comparisons between the global seismic model and slice study model are performed using loads representative of seismic loads only in the absence of gravity, since these are the loads that will be combined with the TOLA results.
7. The effects of axial loads in the tank will be included in the evaluation.
8. The configuration of the AP tanks as well as the AY-based baseline model will be addressed in this evaluation.

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A.3. Methodology

A set of load cases will be indentified to satisfy the comments (above). The load cases will apply representative seismic axial force and waste pressure loads. To speed runtime and reduce postprocessing, the loads will be applied statically to a simplified model. The seismic only results will be obtained through the same procedure as for the global seismic model, which is to solve with combined gravity + seismic and then subtract the gravity portion (solved independently) via postprocessing. The differences in the results between the different mesh densities will be examined and an adjustment factor (ratio) will be determined. The method of combination of the global seismic model results to the TOLA model results will be prescribed, and a single bounding adjustment factor will be determined for use in the combination.

A.4. Model Descriptions

A.4.1. DST Primary Tank Knuckle Geometry

The DST primary tanks have a 12-inch radius knuckle region that joins the tank cylindrical sidewalls to the tank bottom plates. The bottom of the primary tank is supported below by insulating concrete. The insulating concrete extends past the bottom tangent of the knuckle, although the knuckle will not contact the insulating concrete outside of the tangent unless significant deflection occurs. Typical knuckle geometry is shown in Figure A-1.

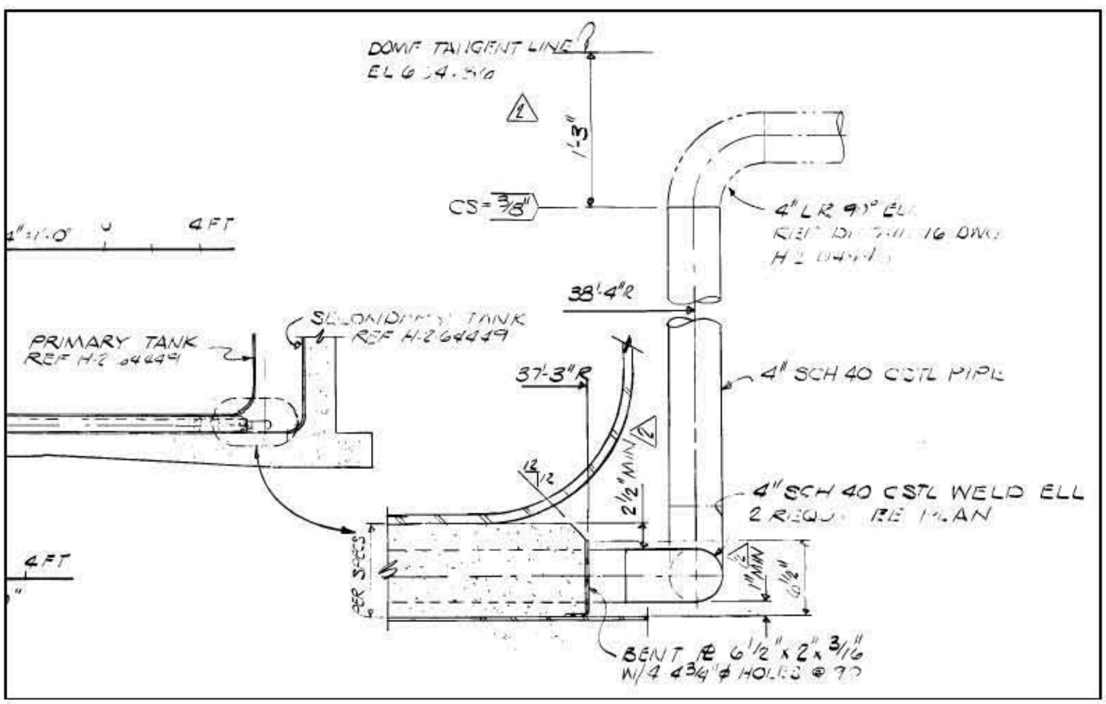

Figure A-1. Knuckle Detail from Drawing AY H-2-64307.

A.4.2. Global Seismic Model Description

A complete description of the AY-based generic seismic model can be found in Section 3.0 of Abatt (2008). A view of the primary tank knuckle and insulating concrete from the global model is shown as Figure A-2.

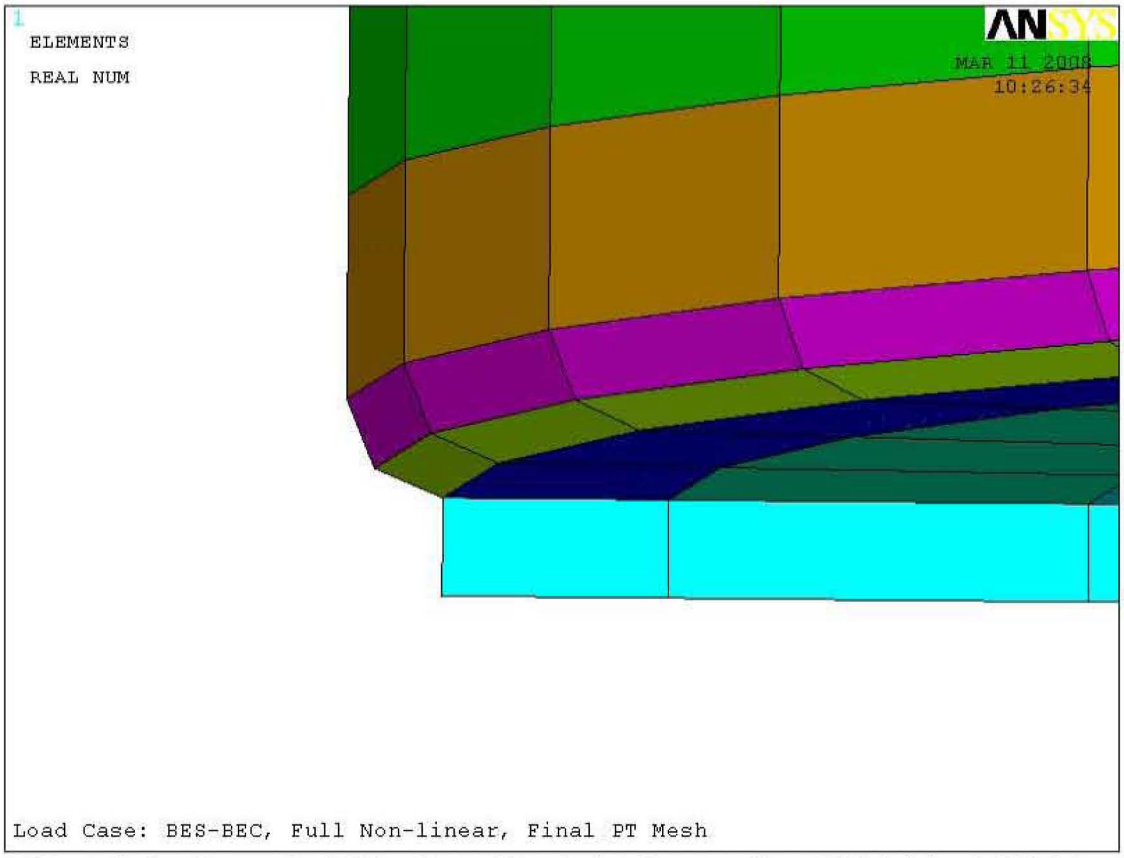

Figure A-2. Primary Tank Knuckle and Insulating Concrete from Global Seismic Model.

The property configuration used for this evaluation is AY tank Best Estimate Soil, Best Estimate Concrete, Lower Bound Anchor Bolt Secant Modulus (AY-BES-BEC-LBmod).

A.4.3. Slice Study Model

The slice model is based directly on the global seismic model, but with the following simplifications and modifications:

- To create the study model, the global seismic model is generated, and then a 1 element wide slice is selected for the solution.
- To improve element aspect ratios in the primary tank knuckle at higher mesh resolutions, the mesh is modified to provide an element width of 2 degrees, instead of 9 degrees. The free mesh

in the center region of the model is also adjusted to accommodate the narrower slice. Other than the knuckle itself, this is the only mesh change.

- The waste is removed from the study model. Loads from the waste will be simulated as pressures on the inner surface of the primary tank.
- Symmetry boundary conditions are applied at the slice sides (circumferential) and at the center of the tank (radial).
- The soil boundary conditions are distributed among nodes that were previously coupled to a master node.
- The solution is performed statically.

The purpose of this investigation is to address the local response of the knuckle, not global behavior of the tank. Although the slice model does not capture full three-dimensional effects, it is sufficient for studying the effects of mesh resolution in the lower knuckle.

Figure A-3 shows a full element plot of the study model, and Figure A-4 shows a close-up view of the knuckle region of the study model.

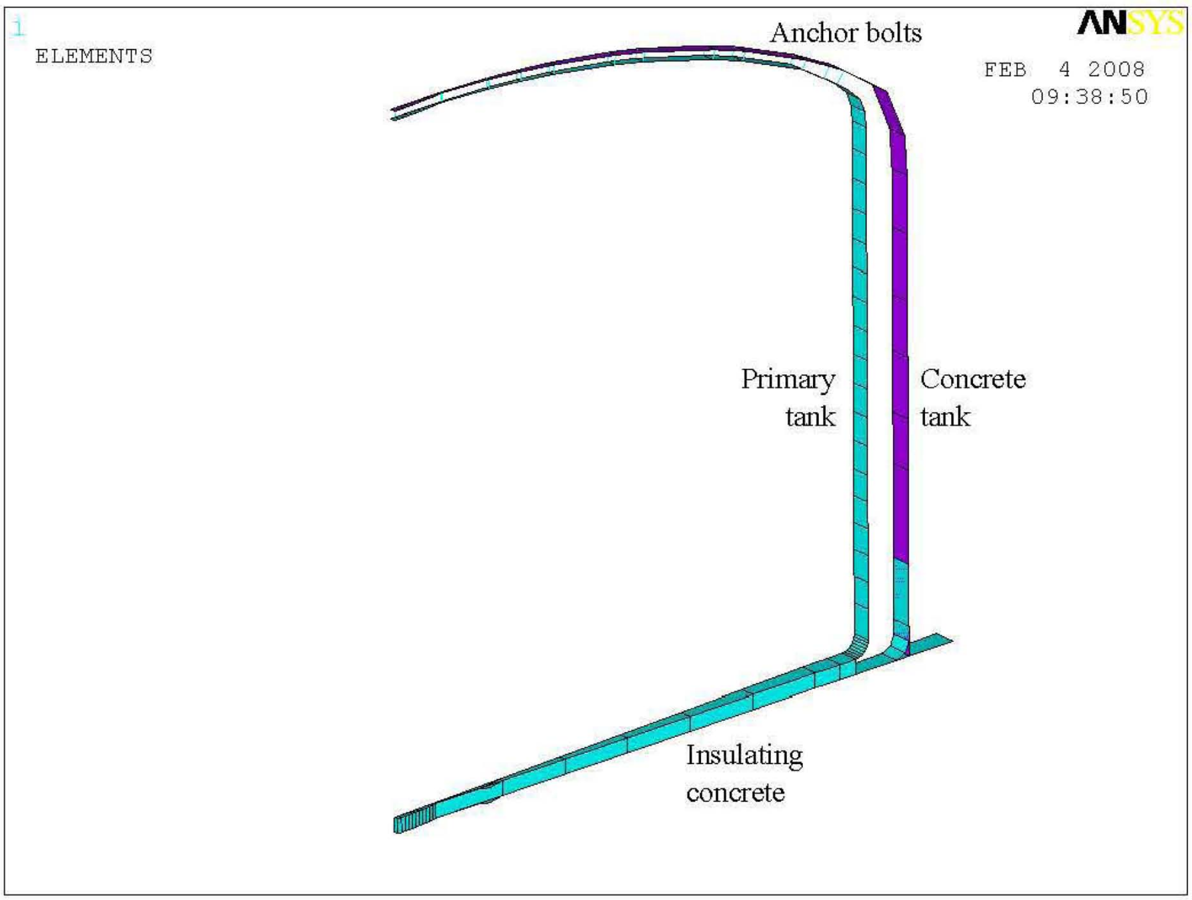

Figure A-3. Study Model Shown Without Soil Elements

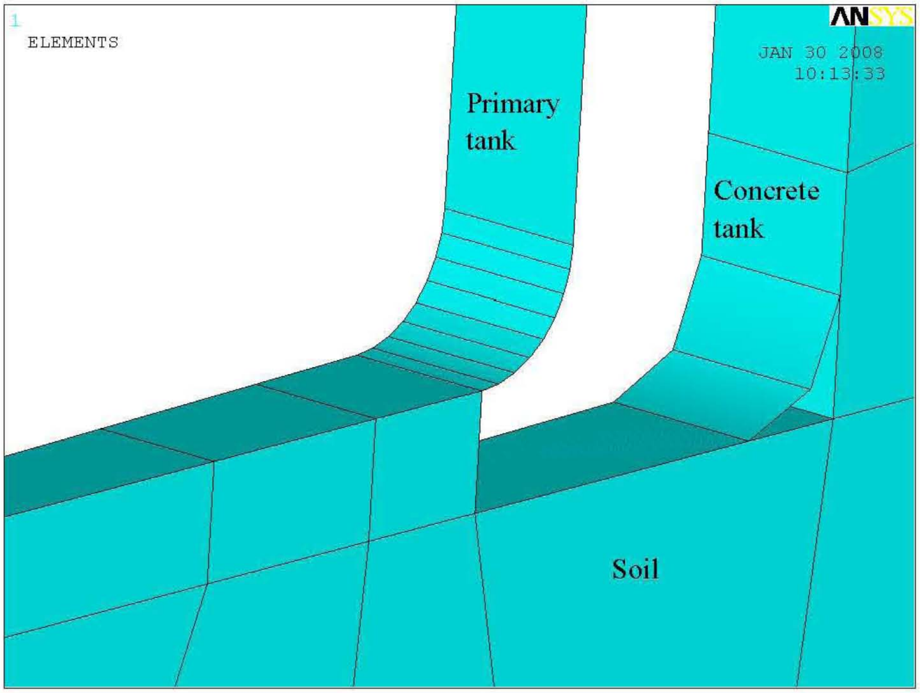

Figure A-4. Primary Tank Knuckle Region of Study Model (8 element knuckle mesh).

A.5. Load Application and Load Case Definition

Per the comments made by Kennedy and Veletsos (see A.2), seismically induced axial and waste pressure loads on the primary tank will be addressed. These loads will be addressed in the following load cases:

1) Seismic waste pressure on primary tank. Waste pressure is taken from the tables of theoretical waste pressure found in Section 8.2 of Abatt (2008). The theoretical values are used for simplicity (the actual results are non-uniform and harder to apply). The theoretical values are compared to the global seismic model results in Abatt (2008), and are found to be similar to the global seismic model FEA results.
2) Axial loads in the primary tank wall. The axial load is applied to the model based on the meridional midplane stress values found in Appendix F Rinker et al 2006. A vertical force will be applied at approximately half height on the primary tank wall such that the resulting stress in the primary tank wall is similar to the meridional midplane stress values found in Rinker and Abatt 2008. The meridional stress is assumed to be completely caused by the seismic structural forces (e.g. overturning). The values reported in Rinker and Abatt 2008are absolute value; therefore the range of loads is potentially reversing. Two opposing axial load subcases will be considered:
    a. Axial tension, based on positive maximum global seismic model stress results (Appendix F Rinker and Abatt 2008) from the primary tank wall.
    b. Axial compression, based on negative maximum global seismic model stress results (Appendix F Rinker and Abatt 2008) from the primary tank wall.

An additional gravity case considering dead weight with waste hydrostatic fluid effects due to gravity will be run as a non-seismic baseline. The load cases will be run with gravity effects (dead weight and waste hydrostatic fluid effects due to gravity) included, and the results of the gravity case will be subtracted from the seismic results. This methodology is the same approach used for producing the global seismic results.

All loads will be applied statically as either a surface pressure or point forces resulting in membrane stress.

A.5.1. Limit of Knuckle Mesh Influence

Results will be presented in the knuckle region and adjacent elements. The limits of influence from the knuckle mesh will be demonstrated by convergence in the results. Convergence is defined as when the relative difference is small, or the overall magnitude is small compared to the maximum values used for calculation of the factor. Beyond the zone of influence no adjustment factor is required.

A.5.2. Methodology Differences and Sensitivity to Applied Loading

The global seismic model is evaluated with dynamic loading, and the study model is evaluated with statically applied loads. For a single load state (as defined by the load cases above), a set of static solutions provide sufficient data on the response of the model to determine the relative differences due to the knuckle mesh.

The loads used in the study model are based on the results provided in Abatt (2008). Those results are maximum absolute values taken from the global seismic model time history analysis. Therefore, the following variations are inherent to this bounding value approach:

- The tank experiences a range of loads that are not reported in detail (absolute maximums only)
- Co-existence of multiple loads (e.g. waste pressure and axial loading) at any place or time cannot be determined without more extensive investigation and correlation

The variations are addressed by determining the sensitivity of the model to the loading. The load will be varied to demonstrate the applicability of the adjustment factor over the expected range of magnitude for the given load type. If the response to the applied loads is nearly linear then the adjustment factor is largely independent of the applied load magnitude. The adjustment factor may then be applied to a range of loads, encompassing the variations.

A.6. Definition of Adjustment Factor

The global seismic model has inadequate mesh resolution in the primary tank knuckle. In order to make sure that conservative stresses are presented for the seismic analyses, a scaling factor needs to be determined to account for the lower mesh resolution in the global seismic model.

In Section 6.2 of this report, the seismic results from the 2 element global seismic model are combined with the results from the 8 element TOLA model to perform an ASME code evaluation of the primary tank. In this process, an adjustment factor must be applied to the global seismic model results to compensate for the lack of mesh resolution in the global seismic model.

A.6.1. Calculation of the adjustment factor

The factor is based on the maximum of the absolute values of meridional and hoop stresses from the study model with 2 and 8 element meshes. The factor is determined by the following steps (performed in a spreadsheet).

1. List stress results by element
2. The knuckle zone of influence is determined by reviewing convergence of the different mesh results.
3. Only results within the zone of influence are applicable for factor use. However, to compare the full range of knuckle results, calculation of the factor must include an element at a common location on each end, regardless of the elements to which the factor is to be applied. See the example below for futher explanation.
4. Take the absolute value of the results.
5. Find the maximum of the absolute values for both 2 element and 8 element results (independent of location)
6. Divide the pair of results found above: 8 element divided by 2 element (independent of location)

It is recognized that other comparison algorithms could be used, but this recommendation uses the method described here.

The calculation of the adjustment factors for each load case is summarized in a table following the graphical presentation of the results.
The adjustment factor and the zone of influence will be determined for each load case. After that, a single bounding factor and zone of influence will be concluded.

A.6.2. Example factor calculation using identical results:

In this example, and in the actual results following, the results used are obtained from elements, and therefore located at the element centroid. The plots will show straight line interpolation between data points to aid comparison and reveal trends. The X-axis on all plots is an arbitrary sequence that indicates the progression of elements from the wall to the floor, where the knuckle extends from element 1 to 8. Additional data points on either side of the knuckle are included to show the limits of the knuckle mesh influence.

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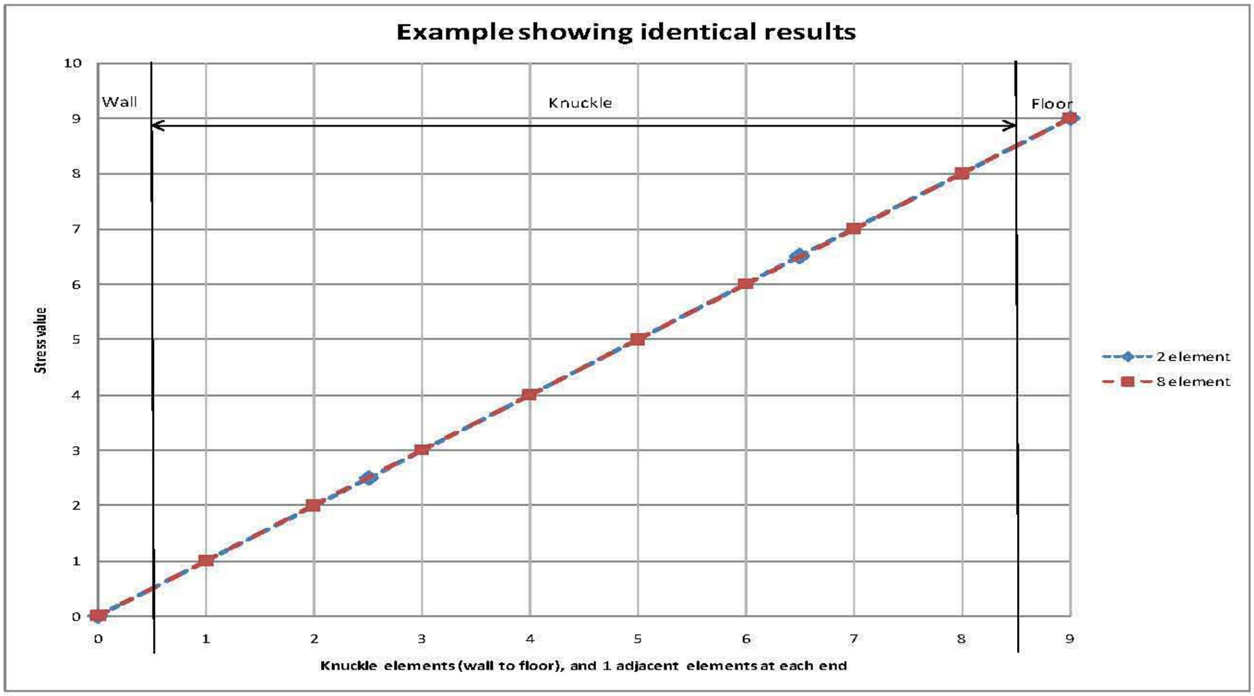

Knuckle elements are highlighted. The 2 element mesh does not align with the 8 element mesh, therefore the location is noninteger. Elements 0 and 9 (and beyond) have the same location.

8 element				2 element			
element	stress			element	stress		
0	0			0	0		
1	1			2.50	2.5		
2	2			6.50	6.5		
3	3			9	9	<- max	
4	4						
5	5						
6	6						
7	7						
8	8						
9	9	<- max					
							Factor
Max abs value	9.00			Max abs value	9.00		1.00

The factor is 8e/2e = 9/9 = 1.0.

Note that if the common element at each end is not included, the factor is 8/6.5 = 1.23, which is clearly incorrect, since the data trend is identical. The common element must be included to ensure that no difference in *alignment* of the element centroids inadvertently leads to a different *range* of data being considered (in this example 1 to 8 vs 2.5 to 6.5).

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A.6.3. Application of the adjustment factor

The method of combining the results must be consistent with the method of calculating the adjustment factor. The adjustment factor must be applied to the global seismic model results within the knuckle zone of influence. The single bounding factor and zone of influence must be used when the loading involves an indeterminate combination of the load types addressed in the load cases.

The dead weight portion of the seismic load from the global seismic model is subtracted from the results before combination; therefore an adjustment factor is applied to seismic loads for a consistent approach.

The recommended method for mapping the global seismic model results to the TOLA model is outlined below. This simplified, conservative method is consistent with the use of a single bounding factor. Follow the process for each stress component (hoop, meridional, top/bottom/membrane, etc.)

1. List the results for the global seismic model elements
2. Determine the maximum stress within the given zone of influence
3. Multiply the above maximum stress by the adjustment factor
4. Add the resulting single value to the TOLA model elements within a location range equal to the zone of influence.

A.7. Results

A.7.1. Format for presentation of results

Results will be summarized and presented in plots showing primary tank meridional and hoop stresses in the knuckle region. Meridional and hoop stresses will be labeled SM and SH, respectively. The top, middle, and bottom shell surface from which the results are retrieved will be identified by _T, _M, and _B respectively. The stress label will be followed by an indicator of the number of elements (e.g. "2e") and a label for the load case. Finally, an additional number (if present) at the end indicates a multiplier on the nominal load. For example, the label "SM_T 8e Pseis_AY 2" represents meridional stress at the top surface on a model with a 8 element mesh, under seismic waste pressure for the AY configuration, using twice the nominal load.

A.7.2. Load Case 1: Pressure Loading

The study model was subjected to a pressure load to simulate the effect of the waste during a seismic event. The pressures are taken from the tables of theoretical waste pressure found in Section 8.2 of Rinker and Abatt (2008). The pressures used the AY tank waste depth of 422 inches with a specific gravity of 1.7. The pressure is applied to the primary tank as a pressure gradient over the depth of the waste. To show the sensitivity of the model to the load, additional loads of one-half and double the

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nominal loading are applied to the study model. The load case also includes gravity effects (dead weight and waste hydrostatic fluid effects due to gravity), which will be subtracted in post processing.

Table A-1. Theoretical Waste Pressures, BES-BEC (copied from Section 8.2 of Rinker and Abatt (2008))

Waste Height Ratio	Waste Height	Hydro static (psi)	Imp (psi)	Conv (psi)	Vert (psi)	Dyn (psi)	Dyn (SRSS) (psi)	Theor Max	Theor Min	Theor Max (SRSS)	Theor Min (SRSS)
0.97	410.75	0.69	1.08	1.38	0.26	2.01	1.77	2.70	-1.32	2.46	-1.08
0.92	386.5	2.18	2	1.25	0.82	3.18	2.50	5.36	-1.00	4.68	-0.32
0.85	359.5	3.84	2.86	1.13	1.43	4.51	3.39	8.34	-0.67	7.23	0.45
0.79	332	5.53	3.59	1.02	2.05	5.78	4.26	11.31	-0.26	9.78	1.27
0.72	305	7.18	4.2	0.93	2.63	6.93	5.04	14.11	0.25	12.22	2.14
0.66	278	8.84	4.73	0.85	3.18	7.99	5.76	16.83	0.85	14.60	3.08
0.59	251	10.50	5.17	0.77	3.7	8.93	6.40	19.42	1.57	16.90	4.09
0.53	225.65	12.05	5.53	0.72	4.15	9.73	6.95	21.78	2.33	19.01	5.10
0.48	202.3	13.49	5.81	0.67	4.54	10.39	7.40	23.88	3.10	20.89	6.08
0.42	179.3	14.90	6.05	0.63	4.89	10.97	7.80	25.87	3.93	22.70	7.09
0.37	156.35	16.31	6.26	0.6	5.2	11.49	8.16	27.80	4.82	24.47	8.15
0.31	131.45	17.84	6.44	0.56	5.49	11.95	8.48	29.79	5.88	26.32	9.36
0.25	104.5	19.49	6.6	0.54	5.76	12.38	8.78	31.87	7.11	28.27	10.71
0.18	77.5	21.15	6.73	0.52	5.97	12.72	9.01	33.87	8.43	30.16	12.14
0.12	50.5	22.81	6.81	0.5	6.11	12.94	9.16	35.74	9.87	31.97	13.64
0.06	24.5	24.40	6.86	0.49	6.2	13.08	9.26	37.48	11.32	33.66	15.14

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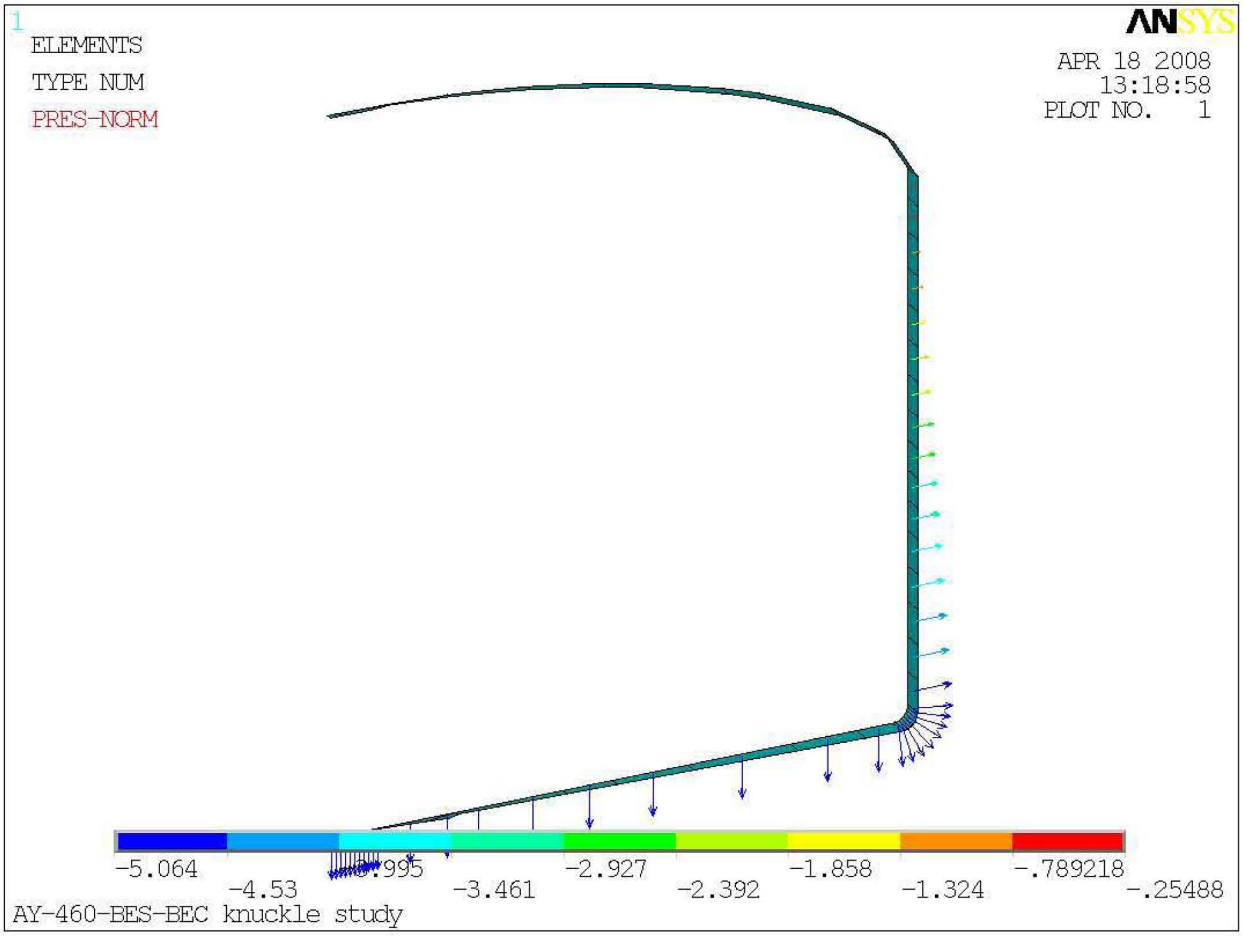

Figure A-5. Element Plot Showing Applied Loads

A.7.3. Results

The meridional and hoop stresses for the 2 and 8 element models are presented in Figure A-6 through Figure A-11.

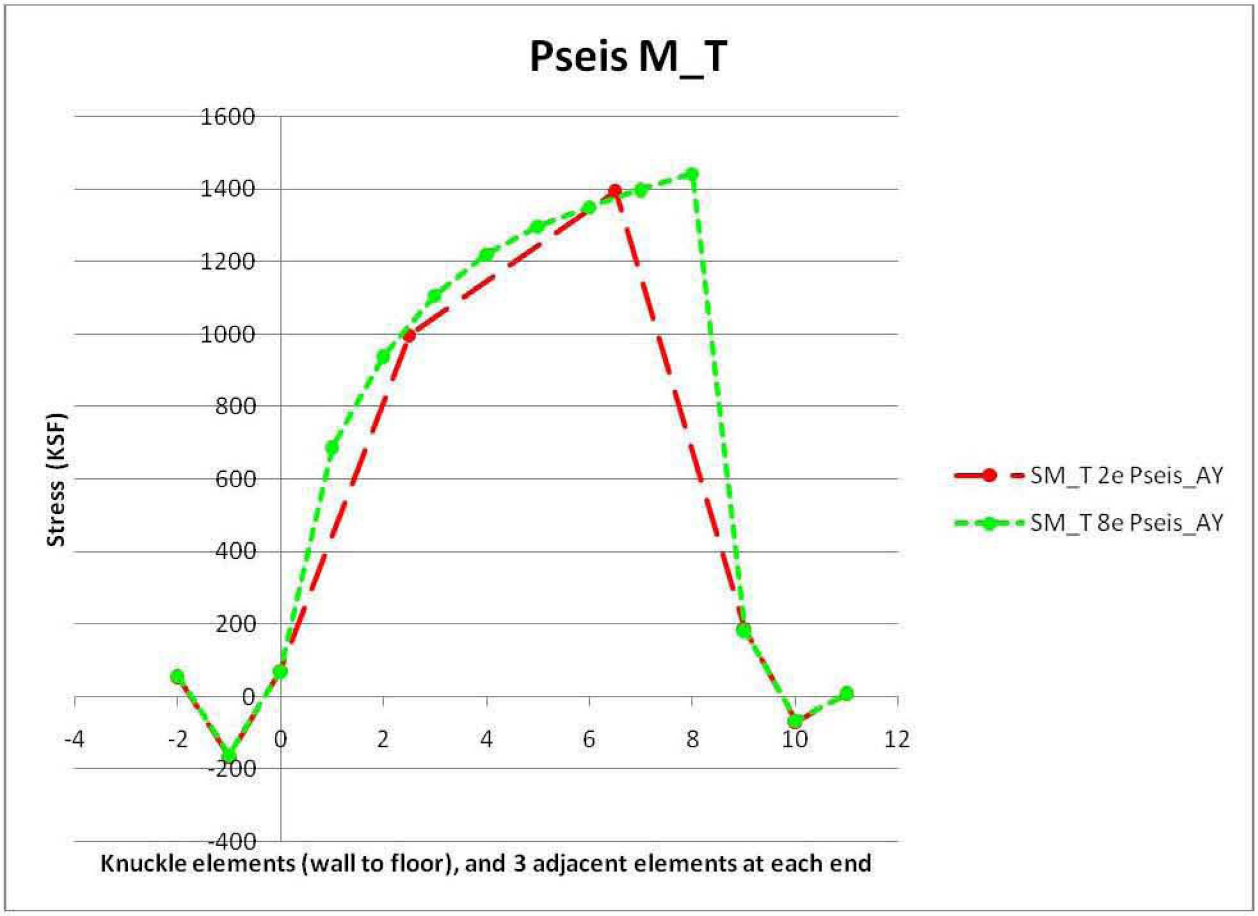

Figure A-6. Knuckle Meridional Stress – Outside Surface (Away from Waste)

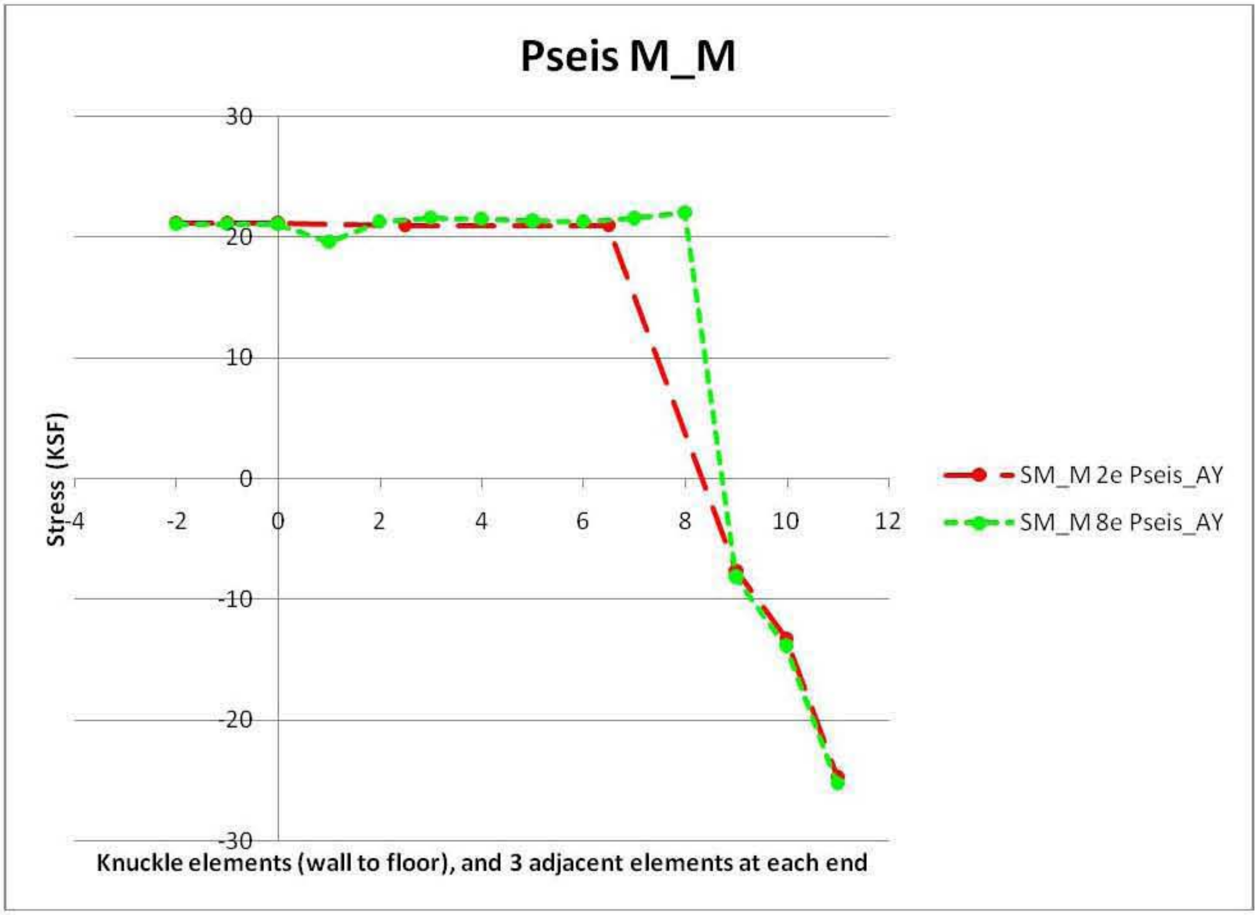

Figure A-7. Knuckle Meridional Stress – Mid-plane Surface

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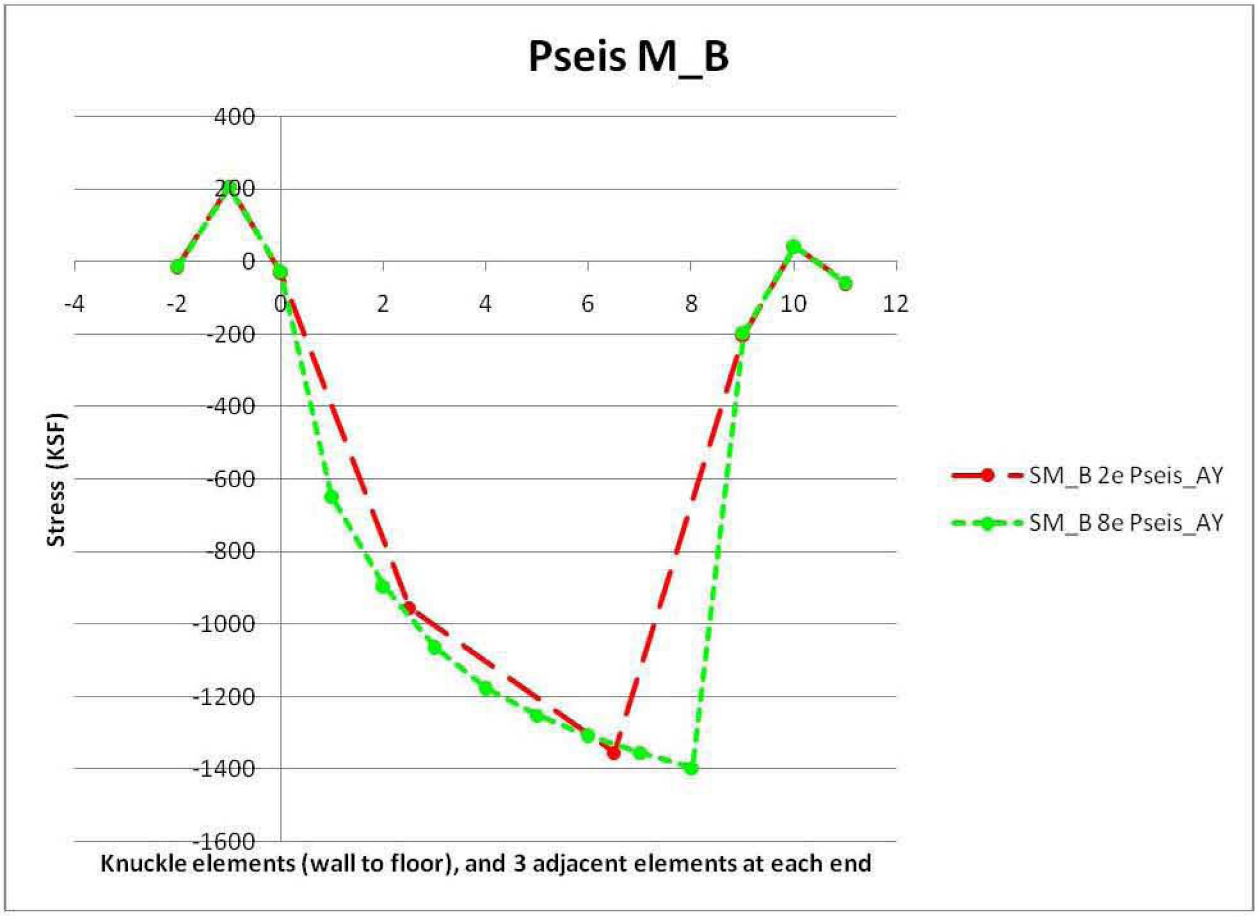

Figure A-8. Knuckle Meridional Stress – Inside Surface (Near Waste)

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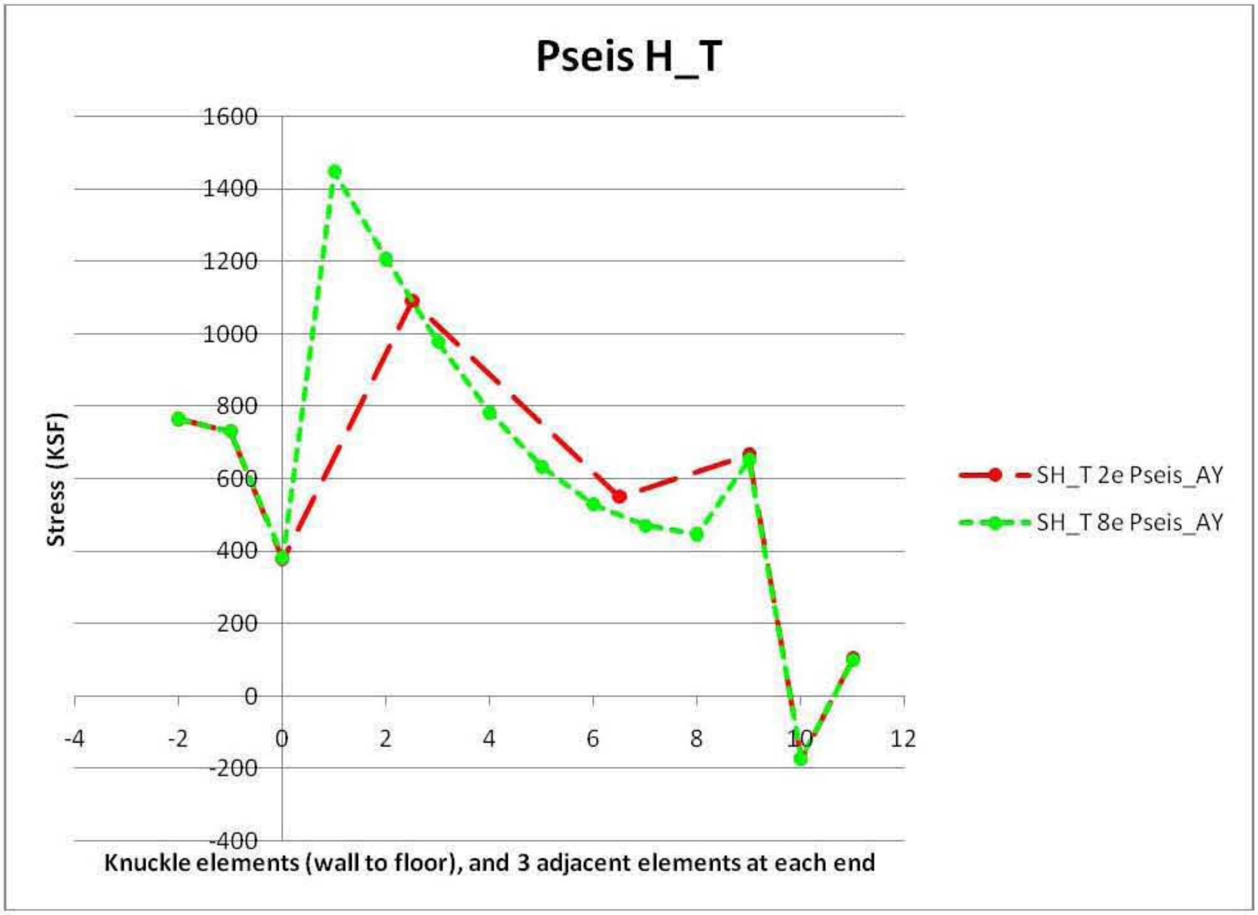

Figure A-9. Knuckle Hoop Stress – Outside Surface (Away from Waste)

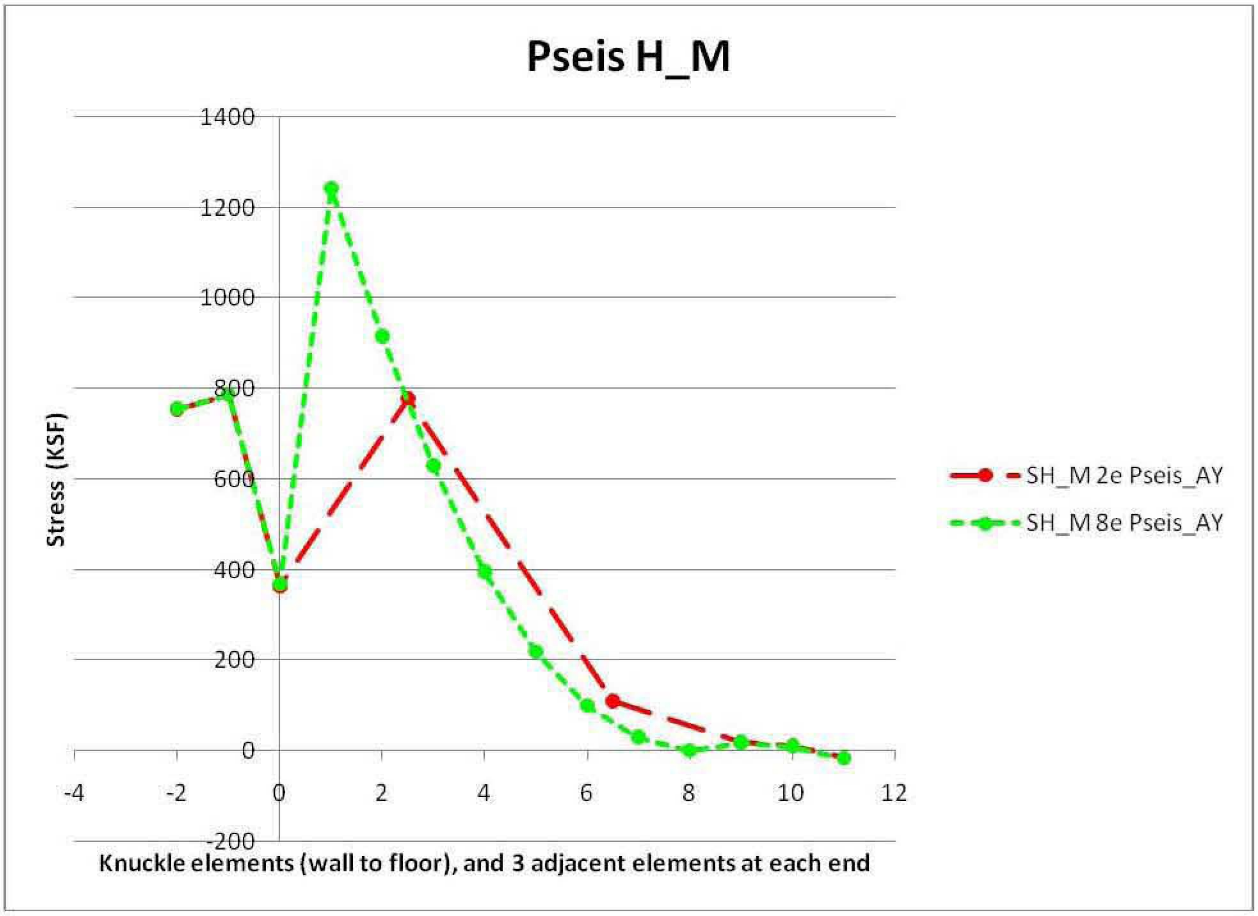

Figure A-10. Knuckle Hoop Stress – Mid-plane Surface

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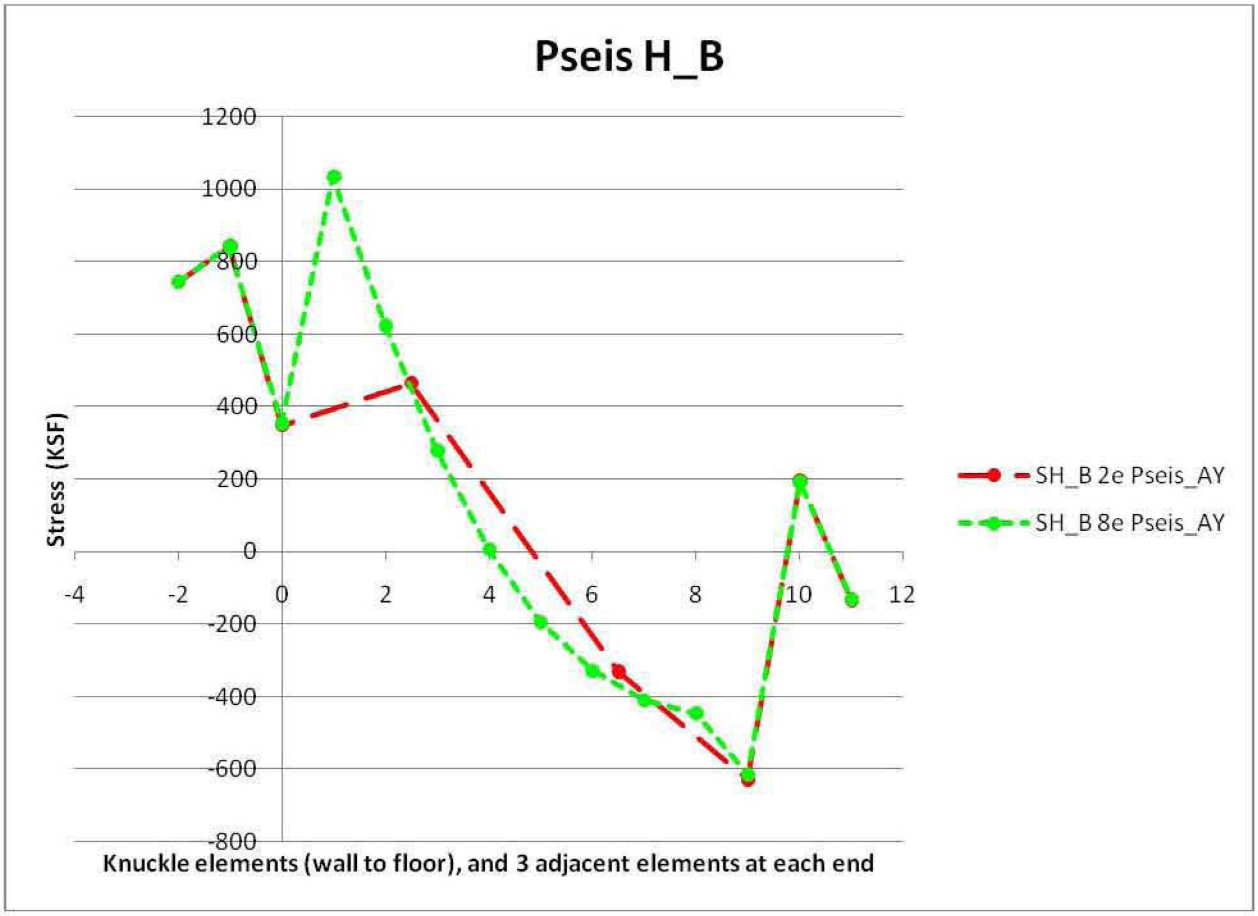

Figure A-11. Knuckle Hoop Stress – Inside Surface (Near Waste)

A.7.4. Seismic Pressure Stress Factors

Table A-2. List of results for 2x load with scale factor calculation

	SM_T	SM_M	SM_B	SH_T	SH_M	SH_B
8e Pseis_AY 2	2883.80	43.96	2795.90	2895.90	2482.30	2068.80
8e Pseis_AY 2X (scaled)	2883.60	43.99	2795.80	2895.20	2481.40	2067.60
Scale factor	1.00	1.00	1.00	1.00	1.00	1.00

Table A-3. List of results for 0.5x load with scale factor calculation

	SM_T	SM_M	SM_B	SH_T	SH_M	SH_B
8e Pseis_AY .5	720.90	10.98	699.00	724.20	620.80	517.50
8e Pseis_AY .5X (scaled)	720.90	11.00	698.95	723.80	620.35	516.90
Scale factor	1.00	1.00	1.00	1.00	1.00	1.00

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The stress scales linearly with the load. Thus, a single adjustment factor may be used, according to methodology described in A.7.

Table A-4. List of results with adjustment factor calculation

Study 2e Pseis_AY							
	Element	**SM_T**	**SM_M**	**SM_B**	**SH_T**	**SH_M**	**SH_B**
0	7827	71.08	21.197	-28.688	378.6	363.8	348.8
2.50	7917	997.6	20.984	-955.6	1091.5	778.4	465.2
6.50	8007	1395.3	21.013	-1353.3	551.6	110.34	-330.95
9	8097	186.58	-7.58	-201.75	666.5	18.877	-628.8
	Max abs value	1395.30	21.20	1353.30	1091.50	778.40	628.80
Study 8e Pseis_AY							
	Element	**SM_T**	**SM_M**	**SM_B**	**SH_T**	**SH_M**	**SH_B**
0	7827	69.022	2.10E+01	-26.928	382.7	368.4	354
1	7917	687.9	19.58	-648.7	1447.6	1240.7	1033.8
2	7962	939.1	21.304	-896.5	1206.4	914.4	622.4
3	8007	1107.4	21.603	-1064.2	978.6	628.8	279
4	8052	1220.4	21.463	-1177.6	783.6	394.7	5.88
5	8277	1296.5	21.321	-1253.9	633	218.71	-195.53
6	8322	1351.5	21.298	-1308.9	529.6	99.9	-329.87
7	8367	1398.9	21.542	-1355.8	470.5	30.3	-410
8	8412	1441.8	21.995	-1397.9	447.9	0.37	-447.2
9	8637	181.81	-8.13	-198.04	651.9	18.424	-615.1
	Max abs value	1441.80	22.00	1397.90	1447.60	1240.70	1033.80
		Pseis_AY factors (max)	**Pseis_AY factors (max)**	**Pseis_AY factors (max)**	**Pseis_AY factors (max)**	**Pseis_AY factors (max)**	**Pseis_AY factors (max)**
		1.03	1.04	1.03	1.33	1.59	1.64

For seismic meridional stresses in the knuckle, the ratio of the 8 element mesh to the 2 element mesh produces a correction factor of 1.05. For seismic hoop stresses in the knuckle, the ratio of 8 element mesh to the 2 element mesh produces a correction factor of 2.22. To ensure conservative analyses, the primary tank knuckle seismic meridional and hoop stresses should both receive a stress factor of at least 2.22.

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A.7.5. Load Case 2: Upward Axial Force

A positive vertical force will be applied at approximately midway up the primary tank wall such that the resulting stress in the primary tank wall is similar to the meridional midplane stress values found in Appendix F Rinker and Abatt 2008. To show the sensitivity of the model to the load, additional loads of one-half and double the nominal loading are applied to the study model. The load case also includes gravity effects (dead weight and waste hydrostatic fluid effects due to gravity), which will be subtracted in post processing.

The wall extends from path location 508" to 851". At the nominal load magnitude, the meridional midplane stress in the five primary tank wall elements above the knuckle in the study model is 90 ksf, which is a reasonable match within the range of values shown in Table A-5 for that location.

Table A-5. AP-422-BES-BEC Pri Tank Stress Seismic Only (excerpt from Appendix F Rinker and Abatt 2008)

ANSYS MAXIMUMS BY PATH

M&D Starting Element No.	Path (in.)	Shell Mid-Plane PNNL-AY-2D-NL-BES-BEC Meridional Stress (kip/ft^2) Mid
981	**503.51**	137.84
1001	**527.76**	151.25
1021	**554.76**	122.92
1041	**582.26**	131.39
1061	**609.26**	140.18
1081	**636.26**	144.67
1101	**663.26**	146.55
1121	**688.61**	144.30
1141	**711.96**	139.56
1161	**734.96**	132.39
1181	**757.91**	125.60
1201	**782.81**	73.49
1221	**809.76**	65.13
1241	**836.76**	56.71
1261	**863.76**	47.75

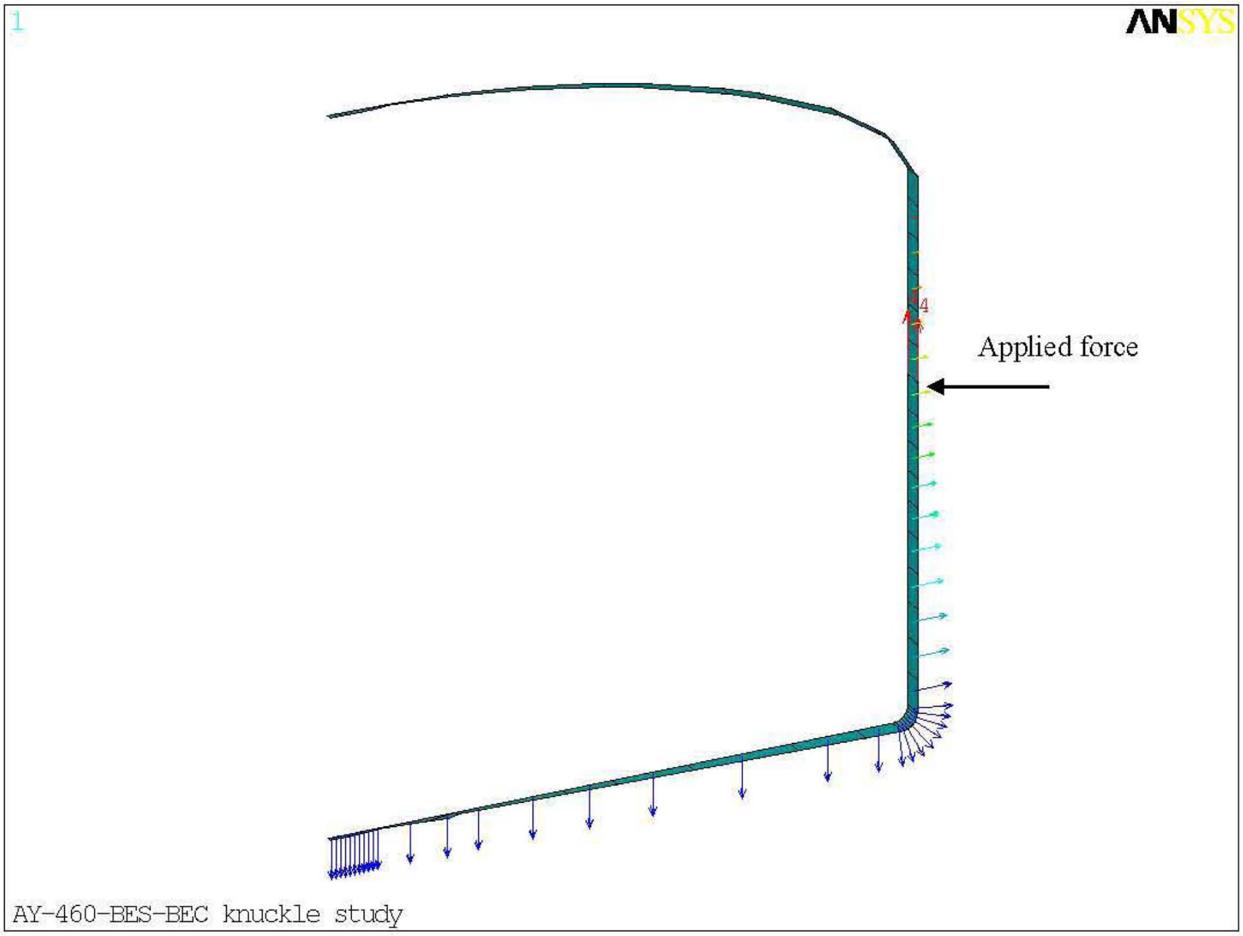

Figure A-12. Element Plot Showing Applied Loads

A.7.6. Results

The meridional and hoop stresses for the 2 and 8 element models are presented in Figure A-13 through Figure A-18.

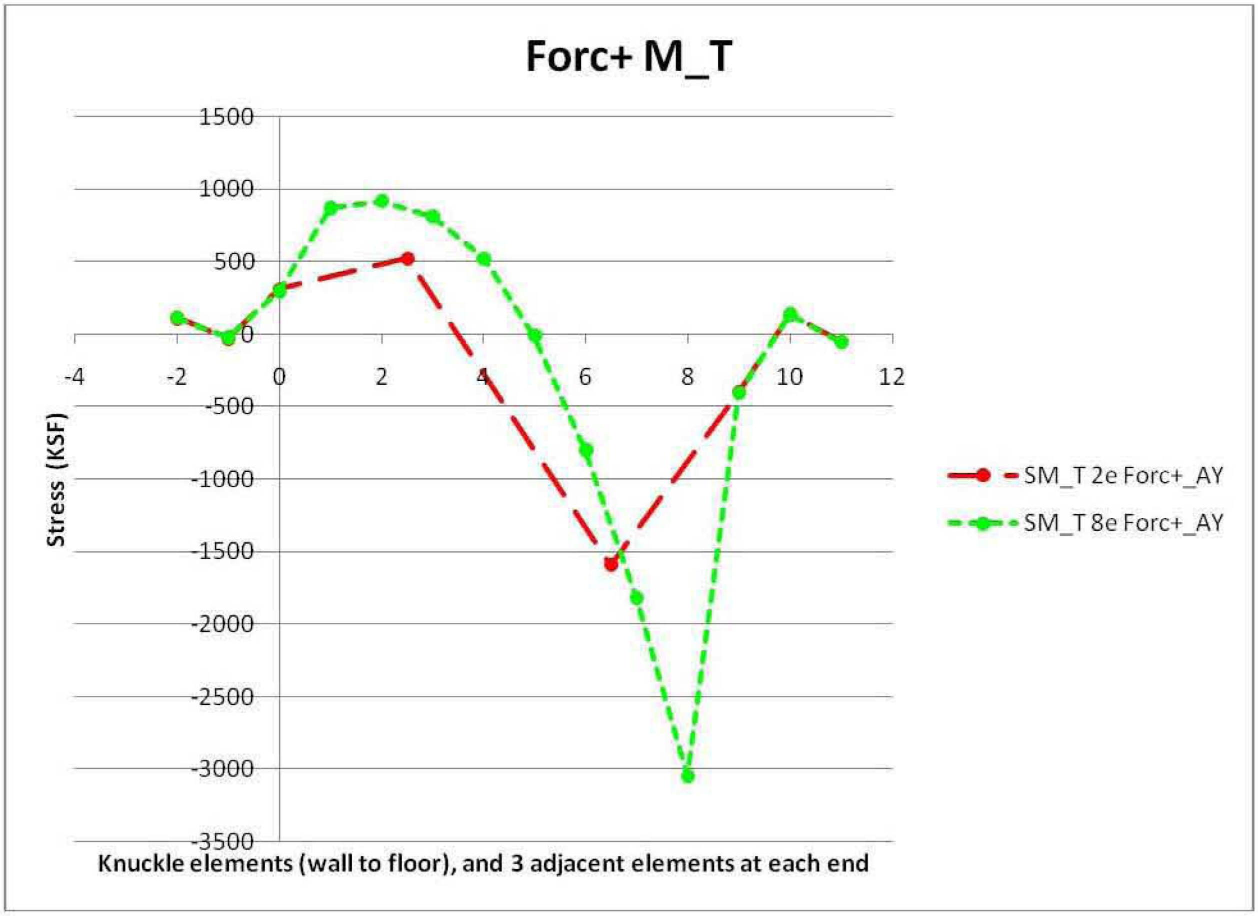

Figure A-13. Knuckle Meridional Stress – Outside Surface (Away from Waste)

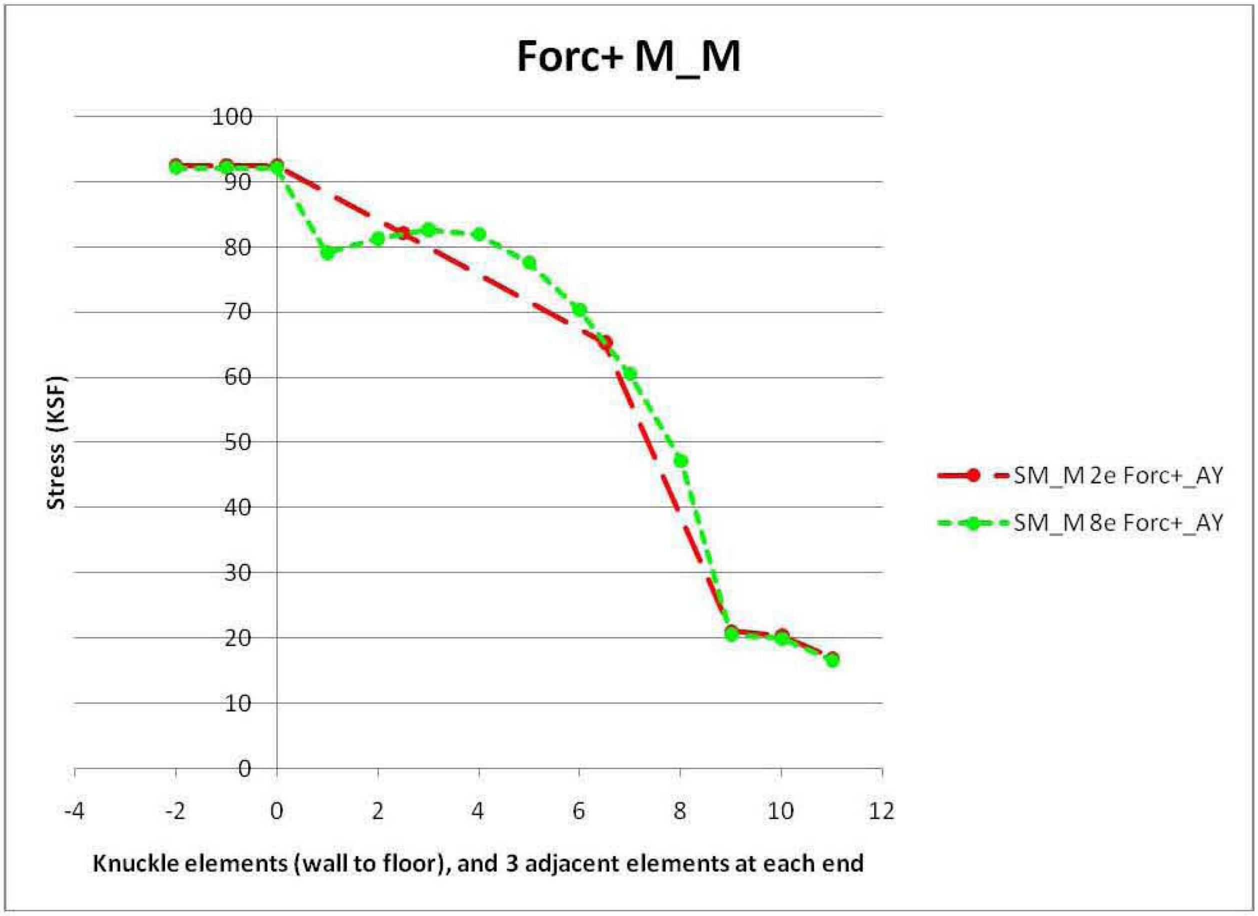

Figure A-14. Knuckle Meridional Stress – Mid-plane Surface

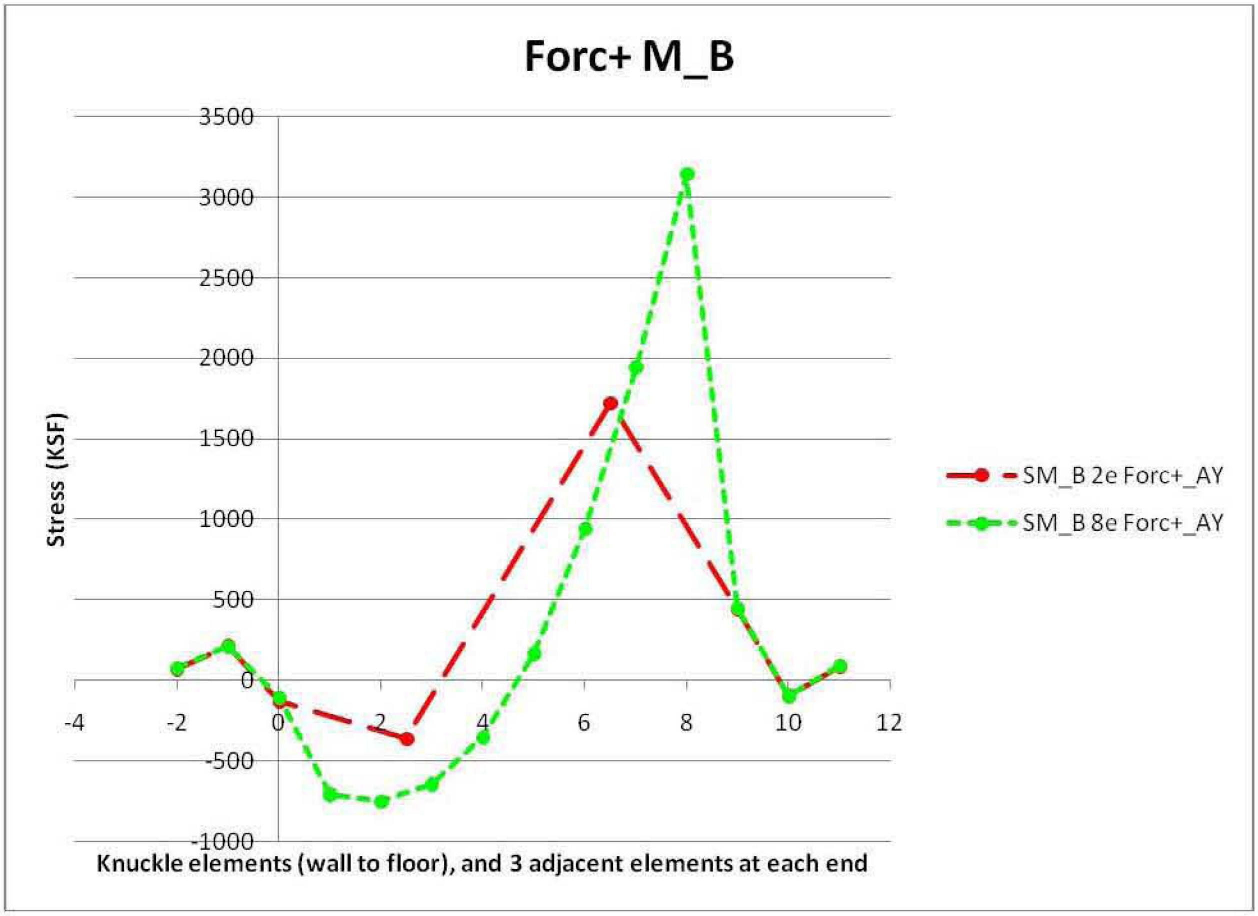

Figure A-15. Knuckle Meridional Stress – Inside Surface (Near Waste)

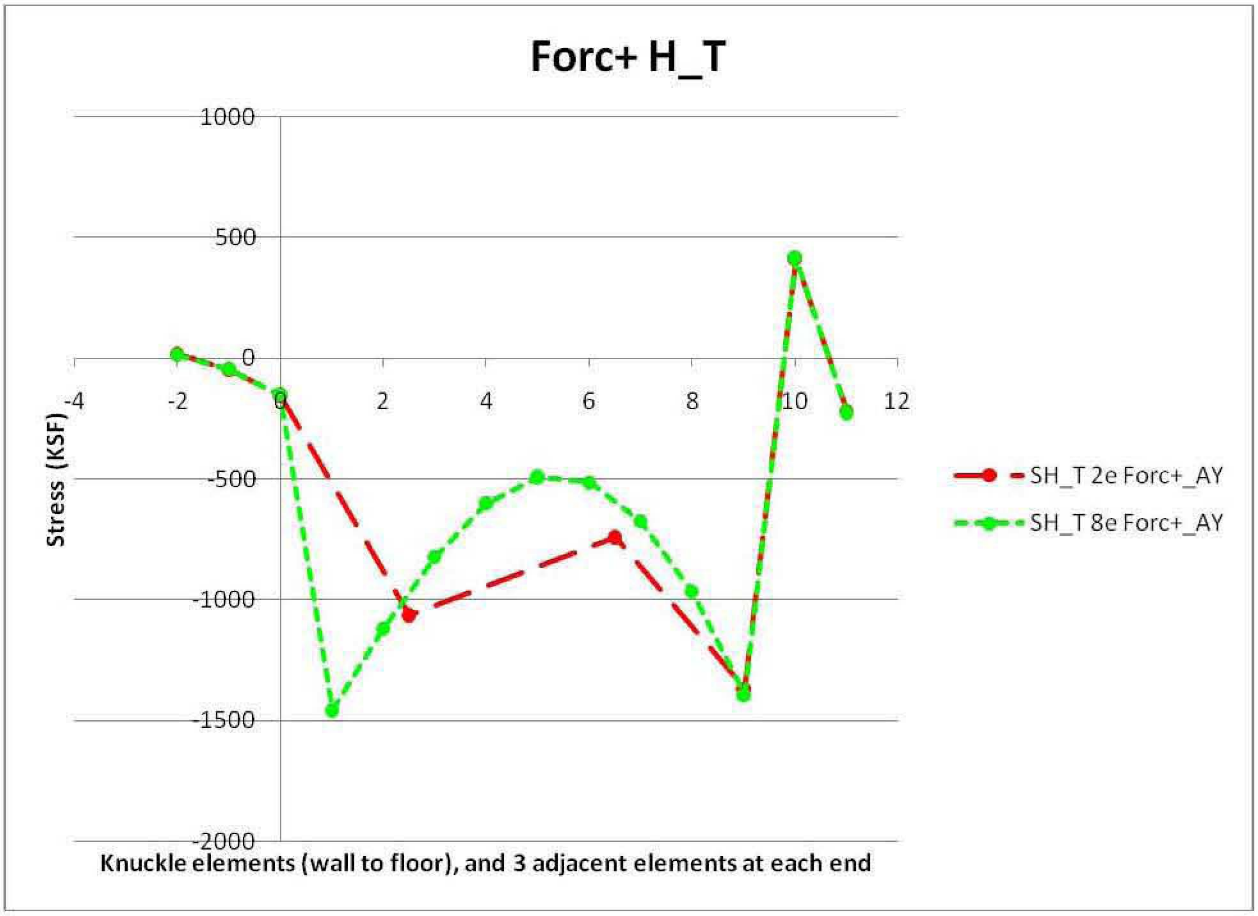

Figure A-16. Knuckle Hoop Stress – Outside Surface (Away from Waste)

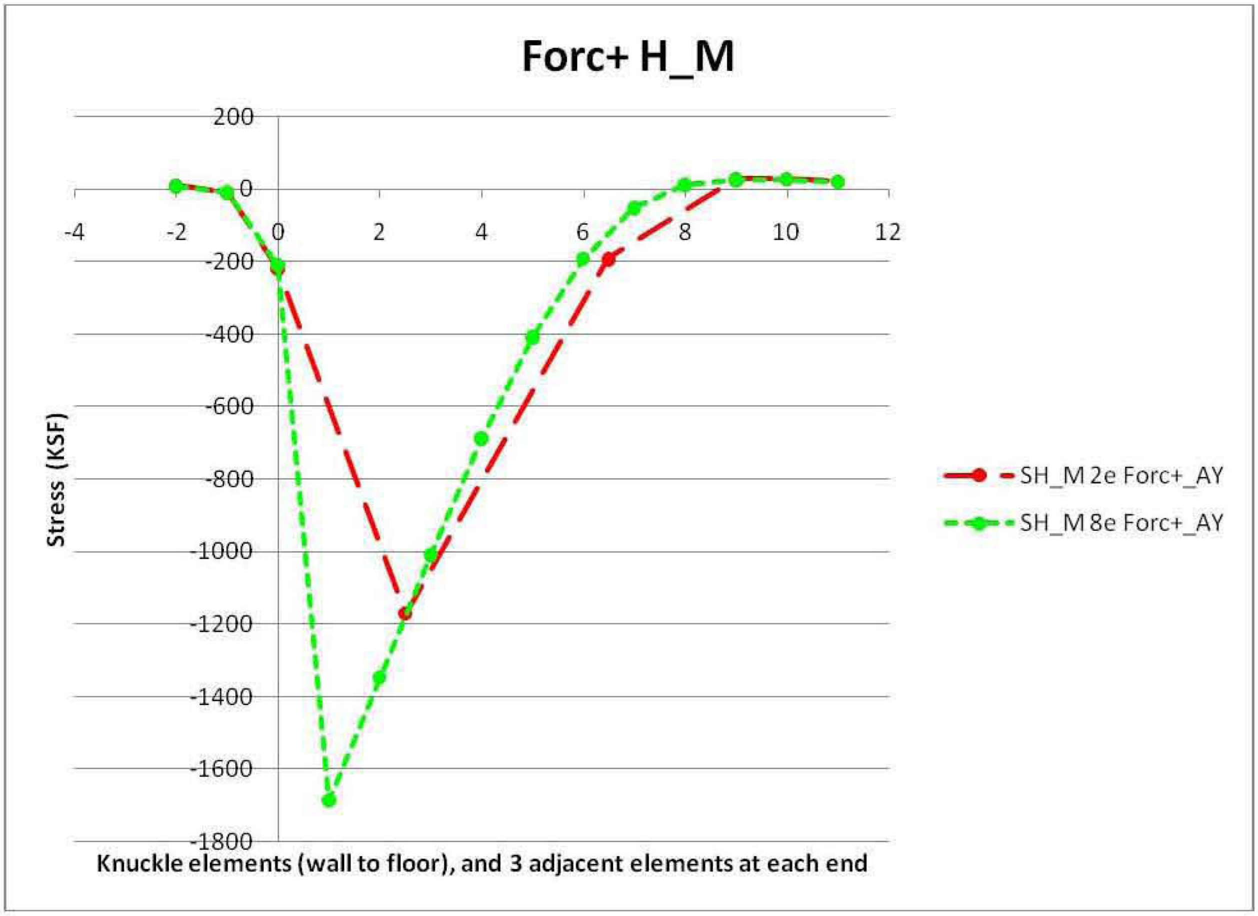

Figure A-17. Knuckle Hoop Stress – Mid-plane Surface

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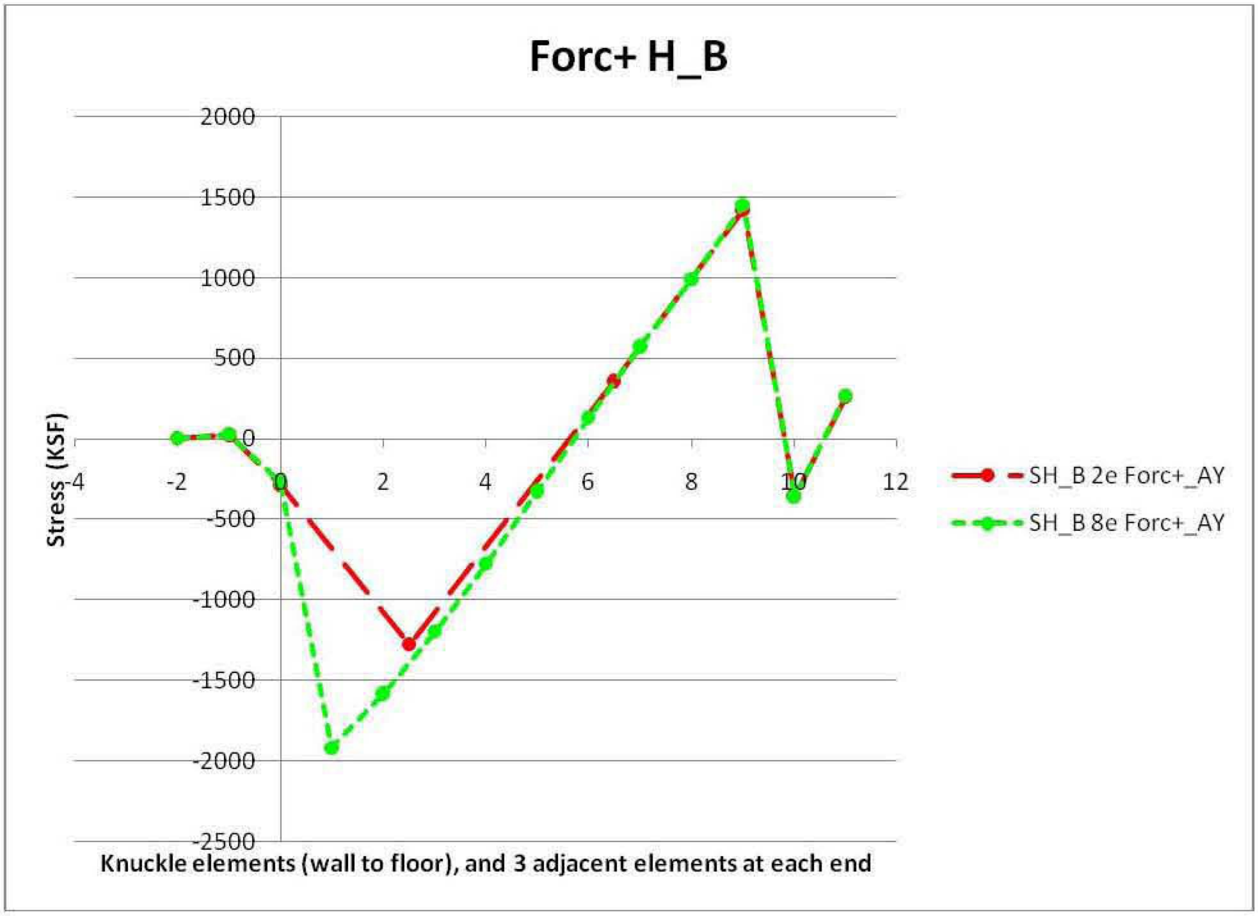

Figure A-18. Knuckle Hoop Stress – Inside Surface (Near Waste)

A.7.7. Seismic Axial Force Stress Factors

Table A-6. List of results for 2x load with scale factor calculation

	SM_T	SM_M	SM_B	SH_T	SH_M	SH_B
8e Forc+_AY 2	5855.41	163.78	6045.88	2944.50	3411.31	3878.14
8e Forc+_AY 2X (scaled)	6093.20	165.26	6282.00	2912.60	3374.00	3835.20
Scale factor	1.04	1.01	1.04	0.99	0.99	0.99

Table A-7. List of results for 0.5x load with scale factor calculation

	SM_T	SM_M	SM_B	SH_T	SH_M	SH_B
8e Forc+_AY .5	1525.20	41.32	1572.30	727.50	842.80	958.00
8e Forc+_AY .5X (scaled)	1523.30	41.32	1570.50	728.15	843.50	958.80
Scale factor	1.00	1.00	1.00	1.00	1.00	1.00

The stress scales approximately linearly with the load. Thus, a single adjustment factor may be used, according to methodology described in A.7.

Table A-8. List of results with adjustment factor calculation

Study 2e Forc+_AY							
	Element	SM_T	SM_M	SM_B	SH_T	SH_M	SH_B
0	7827	311.44	92.511	-126.418	-153.84	-219.43	-285.13
2.50	7917	521.8	82.169	-357.5	-1064.7	-1170.6	-1276.63
6.50	8007	-1591.4	65.392	1722.2	-742	-191.74	358.48
9	8097	-399.46	21.04	441.56	-1368.2	27.208	1422.57
	Max abs value	1591.40	92.51	1722.20	1368.20	1170.60	1422.57
Study 8e Forc+_AY							
	Element	SM_T	SM_M	SM_B	SH_T	SH_M	SH_B
0	7827	292.632	9.21E+01	-108.43	-148.9	-208.99	-269.18
1	7917	868.5	79.112	-710.3	-1456.3	-1687	-1917.6
2	7962	914.2	81.269	-751.6	-1117.6	-1349	-1580.52
3	8007	811.9	82.631	-646.6	-822.4	-1010.3	-1198.25
4	8052	520.9	81.928	-357.2	-600.3	-688.59	-776.81
5	8277	-11.5	77.608	166.7	-490.3	-408.75	-327.16
6	8322	-800.8	70.353	941.5	-514.4	-192.38	129.65
7	8367	-1820.8	60.475	1941.7	-675	-51.07	572.83
8	8412	-3046.6	47.224	3141	-966.06	12.43	990.88
9	8637	-407.8	20.54	448.87	-1394.9	26.66	1448.2
	Max abs value	3046.60	92.11	3141.00	1456.30	1687.00	1917.60
		Forc_AY factors (max)	Forc_AY factors (max)	Forc_AY factors (max)	Forc_AY factors (max)	Forc_AY factors (max)	Forc_AY factors (max)
		1.91	1.00	1.82	1.06	1.44	1.35

For seismic meridional stresses in the knuckle, the ratio of the 8 element mesh to the 2 element mesh produces a correction factor of 1.91. For seismic hoop stresses in the knuckle, the ratio of 8 element mesh to the 2 element mesh produces a correction factor of 1.50. To ensure conservative analyses, the primary tank knuckle seismic meridional and hoop stresses should both receive a stress factor of at least 1.91.

A.7.1. Load Case 3: Downward Axial Force

The loading is the same as for upward axial force, except the sign of the vertical force is negative.

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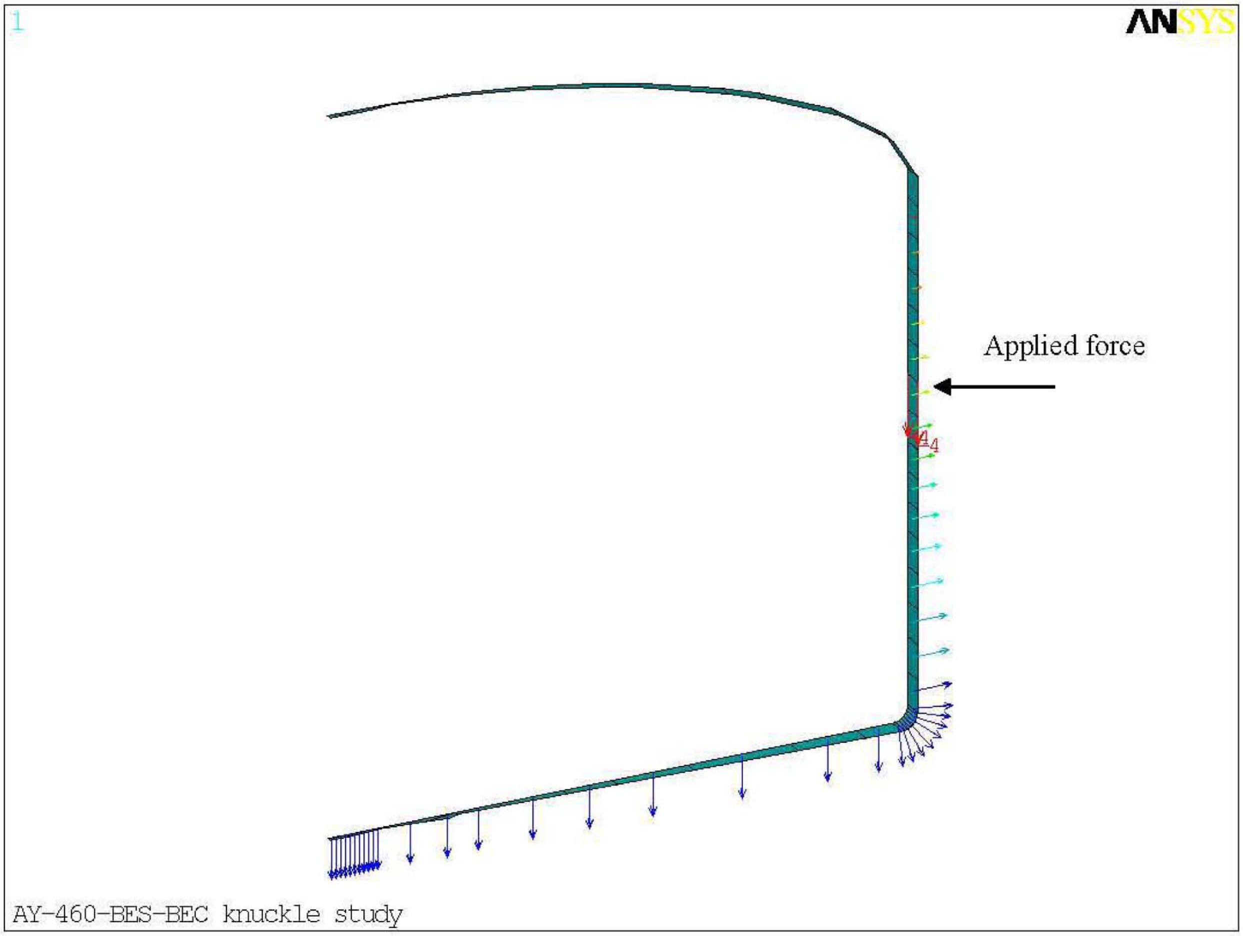

Figure A-19. Element Plot Showing Applied Loads

A.7.2. Results

The meridional and hoop stresses for the 2 and 8 element models are presented in Figure A-13 through Figure A-18.

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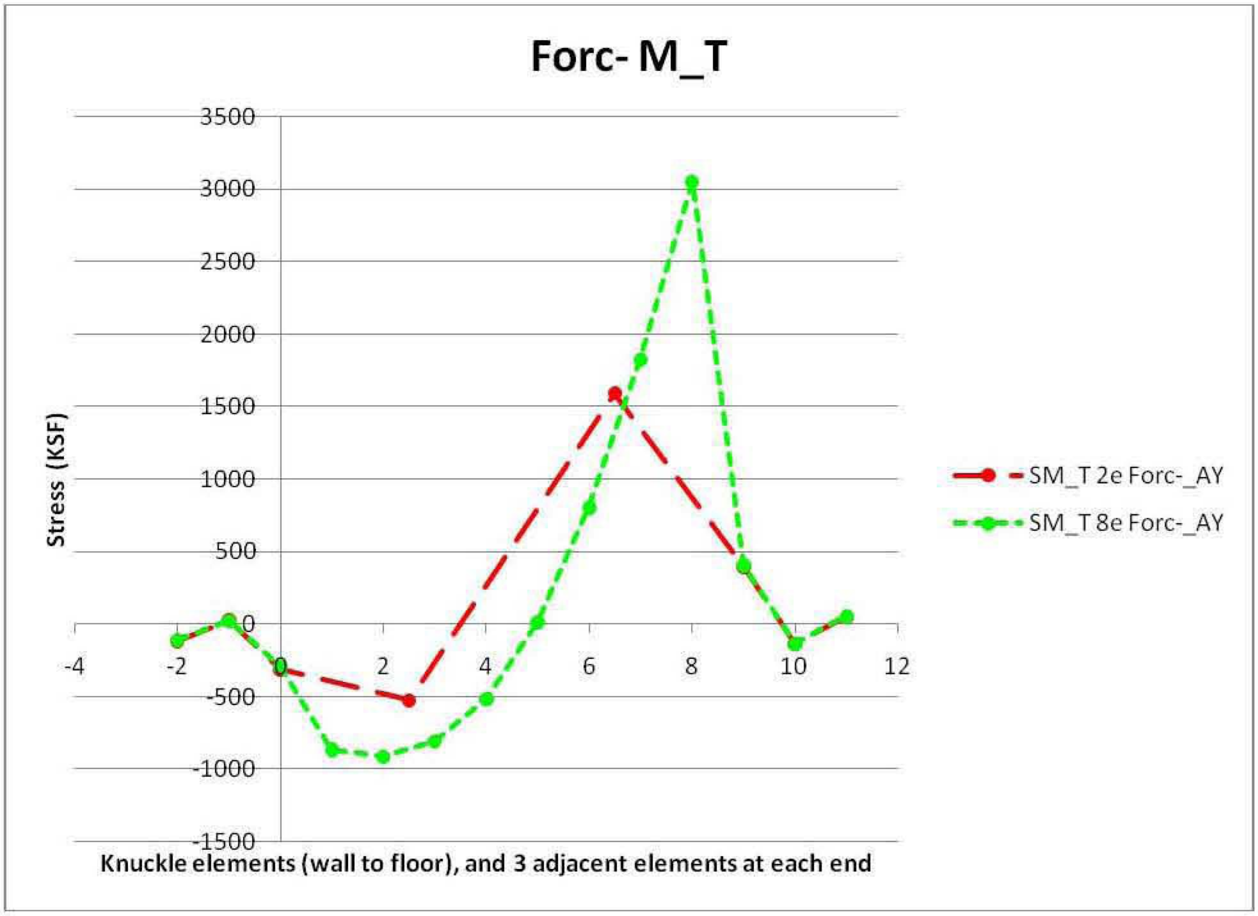

Figure A-20. Knuckle Meridional Stress – Outside Surface (Away from Waste)

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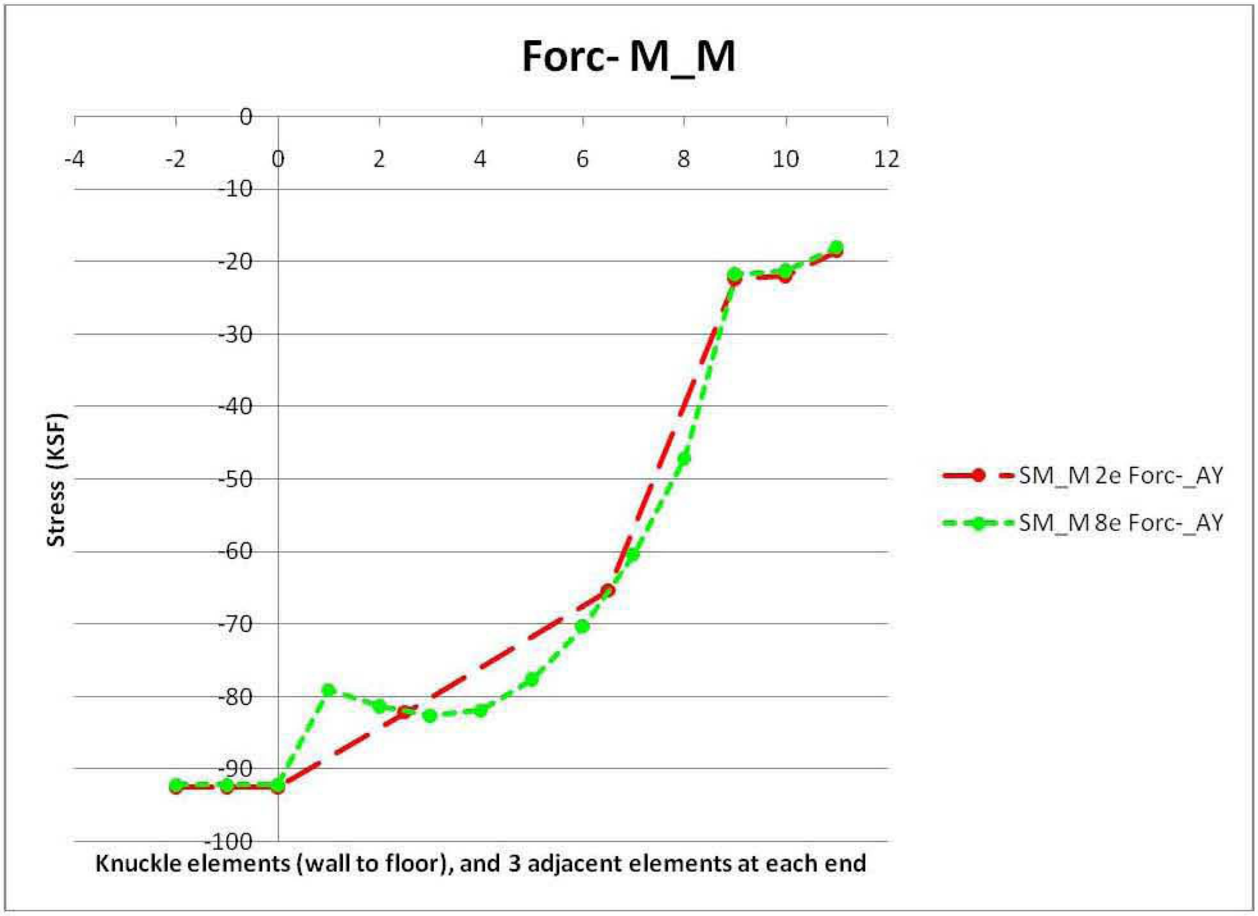

Figure A-21. Knuckle Meridional Stress – Mid-plane Surface

RPP-RPT-28968 Rev. 1

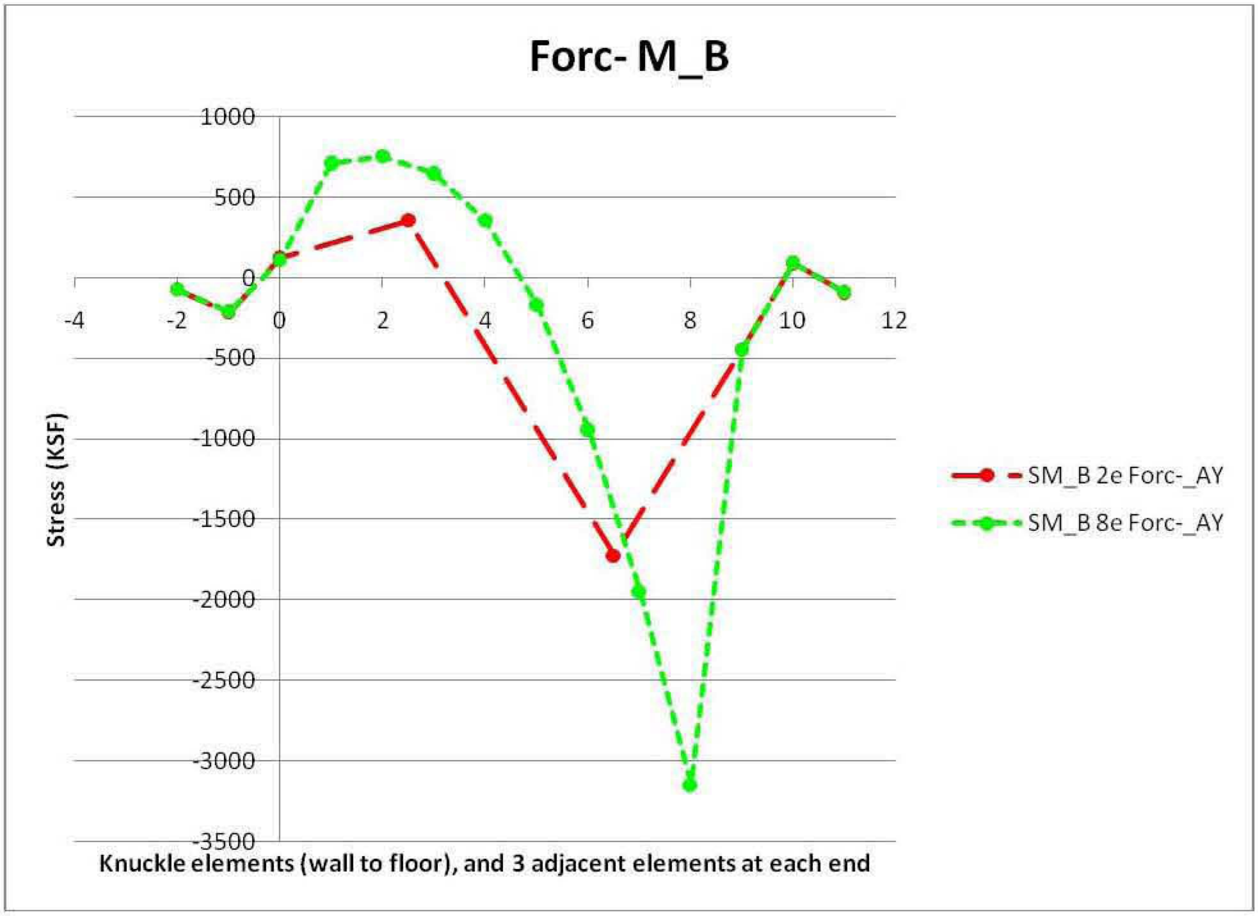

Figure A-22. Knuckle Meridional Stress – Inside Surface (Near Waste)

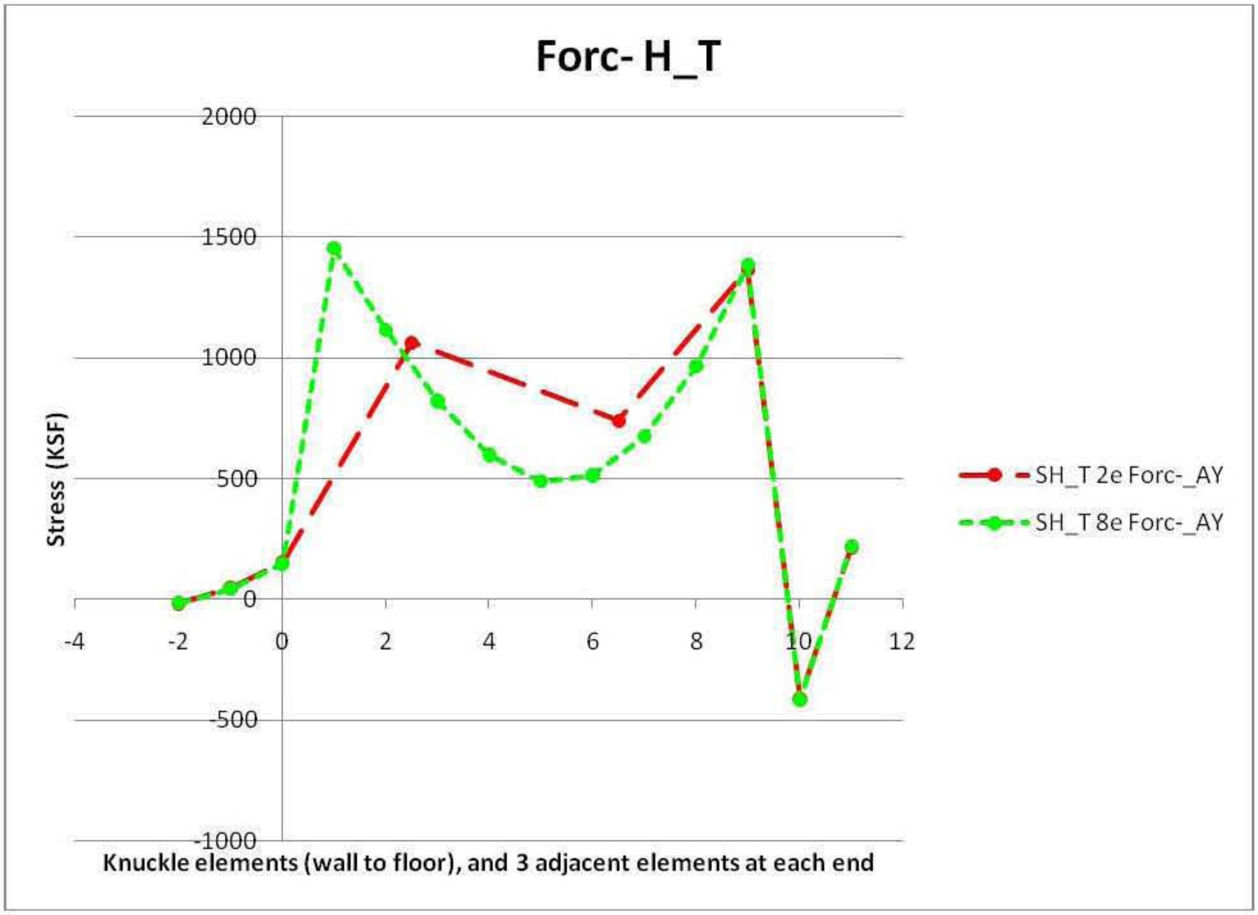

Figure A-23. Knuckle Hoop Stress – Outside Surface (Away from Waste)

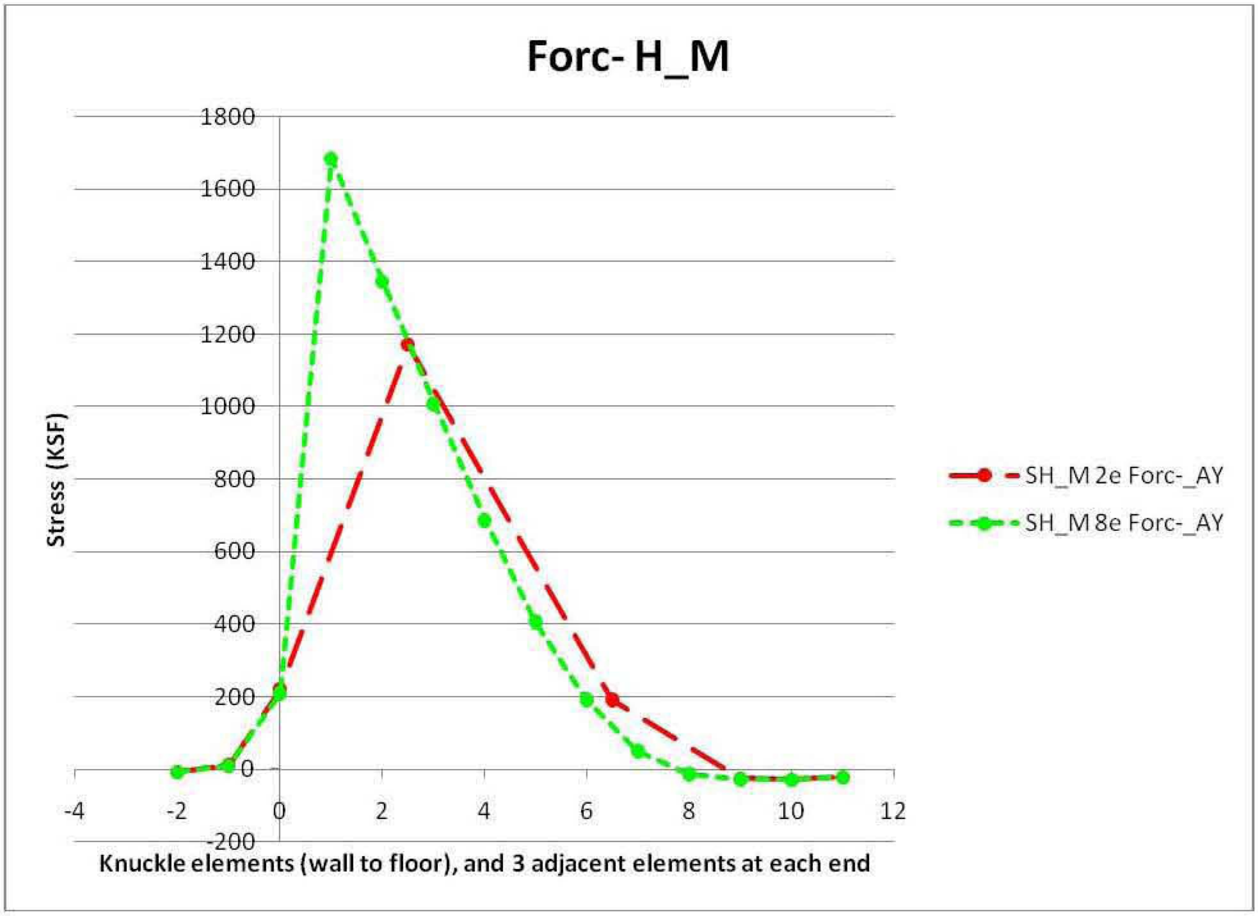

Figure A-24. Knuckle Hoop Stress – Mid-plane Surface

RPP-RPT-28968 Rev. 1

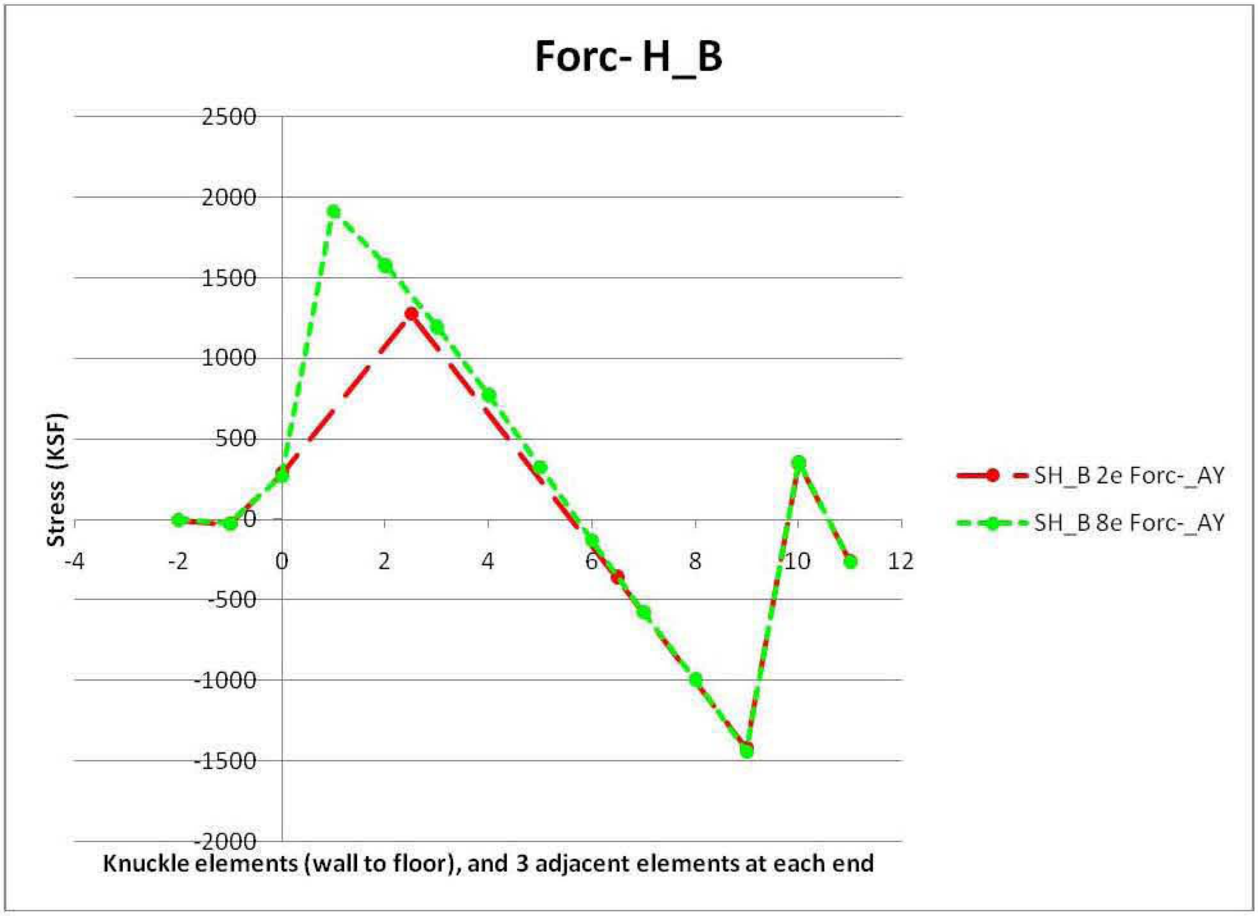

Figure A-25. Knuckle Hoop Stress – Inside Surface (Near Waste)

A.7.3. Seismic Axial Force Stress Factors

Table A-9. List of results for 2x load with scale factor calculation

	SM_T	SM_M	SM_B	SH_T	SH_M	SH_B
8e Forc-_AY 2	6079.50	165.20	6269.10	2915.00	3376.90	3838.70
8e Forc-_AY 2X (scaled)	6102.00	184.21	6290.80	2908.80	3369.60	3830.40
Scale factor	1.00	1.12	1.00	1.00	1.00	1.00

Table A-10. List of results for 0.5x load with scale factor calculation

	SM_T	SM_M	SM_B	SH_T	SH_M	SH_B
8e Forc-_AY .5	1528.20	41.31	1575.40	726.60	841.60	956.60
8e Forc-_AY .5X (scaled)	1525.50	46.05	1572.70	727.20	842.40	957.60
Scale factor	1.00	1.11	1.00	1.00	1.00	1.00

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The stress scales linearly with the load. Thus, a single adjustment factor may be used, according to methodology described in A.7.

Table A-11. List of results with adjustment factor calculation

Study 2e Forc-_AY							
	Element	SM_T	SM_M	SM_B	SH_T	SH_M	SH_B
0	7827	-311.44	-92.505	126.432	153.7	219.5	285.1
2.50	7917	-521.5	-82.164	357.2	1063.9	1169.8	1275.6
6.50	8007	1592.2	-65.36	-1723	741.1	190.7	-359.75
9	8097	397.58	-22.3	-442.15	1365.1	-27.788	-1420.7
	Max abs value	1592.20	92.51	1723.00	1365.10	1169.80	1420.70
Study 8e Forc-_AY							
	Element	SM_T	SM_M	SM_B	SH_T	SH_M	SH_B
0	7827	-292.508	-9.21E+01	108.292	148.6	208.8	268.9
1	7917	-867.8	-79.114	709.55	1454.4	1684.8	1915.2
2	7962	-913	-81.263	750.5	1115.9	1347	1578.1
3	8007	-810.3	-82.617	645	820.9	1008.4	1196
4	8052	-518.7	-81.901	354.8	599.4	686.9	774.43
5	8277	14.5	-77.566	-169.6	489.7	407.21	324.83
6	8322	804.5	-70.299	-945	514.1	191.1	-131.94
7	8367	1824.9	-60.41	-1945.7	674.9	49.95	-575.1
8	8412	3051	-47.149	-3145.4	966.2	-13.44	-993.1
9	8637	404.71	-21.75	-448.19	1387.7	-27.261	-1442.2
	Max abs value	3051.00	92.11	3145.40	1454.40	1684.80	1915.20
		Forc_AY factors (max)	Forc_AY factors (max)	Forc_AY factors (max)	Forc_AY factors (max)	Forc_AY factors (max)	Forc_AY factors (max)
		1.92	1.00	1.83	1.07	1.44	1.35

For seismic meridional stresses in the knuckle, the ratio of the 8 element mesh to the 2 element mesh produces a correction factor of 1.92. For seismic hoop stresses in the knuckle, the ratio of 8 element mesh to the 2 element mesh produces a correction factor of 1.50. To ensure conservative analyses, the primary tank knuckle seismic meridional and hoop stresses should both receive a stress factor of at least 1.92.

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A.8. Summary

This appendix establishes a factor that will be applied to the global seismic model lower knuckle stress components to account for loss of accuracy due to the limited two element mesh resolution. This factor will be applied to the lower knuckle stress components from the global seismic model before combining the results with the TOLA model stresses, which uses a more accurate eight element mesh resolution.

In comments on the previous revision of this appendix, reviewers R.P. Kennedy and A.S. Veletsos recommended that the adjustment factor consider seismically-induced effects, specifically seismic waste pressure and axial loads in the primary tank wall. This revision is substantially rewritten based upon the comments.

The effects of the knuckle mesh and seismic loading are evaluated using a simplified slice model based directly on the global seismic model. Two instances of the study model were used; a two element and an eight element knuckle mesh resolution. Three load cases were defined to evaluate the load conditions indicated in the above comments. The load cases are run with a range of load magnitudes found in the global seismic model.

The adjustment factor is based on the maximum of the absolute values of meridional and hoop stresses from the study model with 2 and 8 element meshes.

The results of the evaluation showed:

- The knuckle zone of influence is limited to the knuckle itself (AY). Thus, the effect of the knuckle mesh resolution (and the adjustment required) is localized.
- The stress scales approximately linearly with the load. Thus, a single adjustment factor may be used because the single factor is applicable over the entire range considered. The broad applicability of the factor covers uncertainties and variations in the magnitude of the load.
- The factor for hoop stress is higher for pressure loads than meridional stress.
- The factor for meridional bending stress is highest for axial loads.

An adjustment factor of at least 2.0 is recommended to be applied to the meridional and hoop stresses for the primary tank lower knuckle of the global seismic model. The adjustment factor need only be applied to the knuckle zone of influence elements, which is at most one element beyond the knuckle.

A.9. Conclusion

Due to the possibility of differences in interpretation of this study, an adjustment factor of 3.00 is recommended for the meridional and hoop stresses in the primary tank lower knuckle of the global seismic model.

A.10. References

Abatt, F.G., 2008, *Establishment of Methodology for Time Domain Soil-Structure Interaction Analysis of a Hanford Double Shell Tank*, M&D-2008-004-RPT-01, Rev. 1, prepared by M&D Professional Services, Inc. for Pacific Northwest National Laboratory, Richland, Washington.

Rinker MW, JE Deibler, KI Johnson, NK Karri, SP Pilli, Abatt FG, BG Carpenter,and CA Hendrix. 2006. *Hanford Double-Shell Tank Thermal and Seismic Project – Summary of Combined Thermal and Operating Loads with Seismic Analysis.* RPP-RPT-28968, Rev. 0. Pacific Northwest National Laboratory, Richland, Washington.

Appendix B

Reviewer Comments and Discussion

Appendix B

Reviewer Comments and Discussion

An independent review of the Double Shell Tanks (DST) Thermal and Operating Load (TOLA) and Seismic analyses was conducted by Dr. Robert P. Kennedy of RPK Structural Mechanics Consulting and Dr. Anestis S. Veletsos of Rice University. Their comments are reported in Section B.1. Response to these comments is found in the remainder of this appendix and in the relevant separate reports described herein.

B.1. Reviewer Comments

Additional Comments and Recommendations Concerning
Seismic Evaluation of Hanford Double-Shell Tanks
by
R.P. Kennedy and A.S. Veletsos
May 2006

1. Introduction

Our initial comments and recommendations regarding the seismic evaluation of the Hanford Double-Shell Tanks (DSTs) were presented in Ref. 1 based on our review of the studies reported through July 2005. Our present input refers to the additional studies conducted since then, and it is based on:

- Our review of Refs. 2 through 7; and
- The presentations and ensuing discussions at the Review Meeting of March 20 and 21, 2006, in which we participated to provide an independent oversight and comment on the adequacy and completeness of the approach being used.

Our views and recommendations are presented under the following six topic headings.

2. Use of ANSYS for Soil-Structure Interaction Analyses

The methodology used to evaluate the soil-structure interaction (SSI) effects for the DSTs is described in Ref. 2. It involves the use of the ANSYS computer program in which the analysis is implemented directly in the time domain. Unlike the more commonly used SASSI program which is limited to the analysis of linear, elastic systems, the ANSYS program can also be used to assess the effects of nonlinear, hysteretic actions.

Reference 2 presents the results of a number of comparative analyses implemented using both ANSYS and SASSI. The results obtained by the two approaches are in quite good agreement for system frequencies less than about 10 Hz, but for the higher frequencies, the ANSYS predictions are generally higher than the SASSI. In as much as the natural frequencies of the tank-liquid systems that contribute materially to the desired responses are less than 10 Hz, however, the conservative bias of the ANSYS results is of no practical consequence.

We, therefore, concur with the appropriateness and reliability of the ANSYS program to evaluate the SSI effects of the DSTs, and of the methodology described in Ref. 3. However, we do not concur that it was necessary to have performed the Ref. 3 analyses using ANSYS, but do respect an analyst's preference for and right to use any acceptable approach to a desired end.

The rationale for using ANSYS was to make it possible to account for the effects of potential sliding at the interface of the concrete vault and surrounding soil, and more importantly, the interface of the base of the primary tank and the insulating concrete basemat. Since these effects – as might have been anticipated by simple, exploratory analyses – did not prove to be of practical importance, the SSI analyses could have been performed using the SASSI or some other linear program.

Specifically, starting with a simplified, single-degree-of-freedom idealization of the waste-containing tank, the response of the tank-vault-soil system could have been evaluated using the SASSI program. The resulting response history of the concrete vault could then have been used as input to a refined model of the waste–containing tank, and its response determined either by ANSYS, making due provision for localized nonlinear actions, or by the DYTRAN program.

In the methodology described in Ref. 3, the waste-containing tank, concrete vault, and surrounding soil were analyzed as a single interacting system using the ANSYS program. As noted in Section 6 of Ref. 1, this one-step approach leads to a highly complex model that imposes practical limits to the degree of refinement with which critical regions of the system may be modeled. We believe that the two-step approach referred to above – even when implement exclusively with ANSYS – would have been preferable, as it would have permitted the use of more refined but simpler subsystems which might have led to improved solutions in regions of rapid pressure variation or high stress concentration.

Incidentally, its is not clear why, in the simplified analysis described in Section 7 of Ref. 2, the simple-mass-spring systems used to model the waste-containing tank were attached to the concrete vault at 5 feet from its top. Considering that the tank is supported laterally at both the top and base of the concrete vault, the approximating system should have been similarly supported at the two levels. The appropriate approach is comparable to the one used in Section 8.1.1 of the same reference to evaluate the fluid-structure interaction effects.

3. Fluid-Structure Interaction Analyses of Primary Tanks

References 4 and 5 present the results of fluid-structure interaction (FSI) analyses for the primary tank using the ANSYS and Dytran program, respectively. Solutions for waste heights of both 424 or 422 inches and 460 inches are presented. The results of the two approaches for each of the two waste levels considered are discussed separately in the following subsections.

3.1 ANSYS Results for 424-inch Waste Level. With the exception noted in the following, the solutions for both the rigid and flexible tanks reported in Ref. 4 are in reasonable agreement with the corresponding theoretical solutions. The exception refers mainly to the surface sloshing action of the waste. The ANSYS model severely underpredicts this action; it leads to a maximum slosh-height of only 8 inches, while the corresponding theoretical value is 23.7 inches. This underprediction also adversely affects the accuracy of the hydrodynamic pressures in a shallow region around the top of the primary tank, as these effects are dominated by the sloshing action of the waste.

There are also differences between the theoretical and ANSYS solutions of the impulsive components of response, but these are generally limited to about 13 percent, the ANSYS results being consistently higher than the theoretical.

It is extremely important in our view to understand the reasons for these differences, especially the severe underprediction of the surface slosh-height. Parts of these differences may well be due to differences in the damping values used in the two approaches.

Considering first the impulsive effects, it should be noted that the theoretical solutions for the horizontally excited flexible tank presented in Appendix B of Ref. 4 are for a fundamental impulsive modal damping of 4 percent critical. By contrast, the corresponding damping determined from the decay rate of the free vibrational phase of the impulsive response of the ANSYS solution shown in Fig. 5-3 of Ref. 4 is 2.7 percent critical. The larger damping in the theoretical solution will naturally reduce the response, but the reduction may partly be offset by differences in the natural frequencies of the models used in the two solutions.

Whereas the fundamental natural frequency of the impulsive mode in the theoretical solution presented in Appendix B of Ref. 4 is 7.0 Hz, that of the ANSYS model was determined to be about 7.5 Hz. The response spectrum in Fig. 2-22 of Ref. 4 shows that the spectral pseudo-acceleration and hence the system response at 7.0 Hz is indeed higher than at 7.5 Hz. As a result, the effect of the difference in frequencies is opposite to that of the difference in damping, and the combined effect is expected to be a reduced level of impulsive response and improved agreement between the theoretical predictions and those arrived at by the ANSYS program.

Regarding the convective components of response, it should be noted that whereas the theoretical solution in Appendix B of Ref. 4 is based on a damping value of 0.5 percent critical for the fundamental convective mode, the corresponding damping determined from the free vibrational phase of the response of the ANSYS model in Fig. 5-2 of Ref. 4 is 17 percent of critical. The severe underprediction of the slosh height in the ANSYS solution is clearly due, at least in part, to the higher damping of the ANSYS model.

An additional factor that may contribute to the underestimation of the sloshing action may be the extent to which the waste in ANSYS is modeled as an incompressible, practically inviscid liquid. Additional studies are needed to determine whether the ANSYS code can indeed accurately predict the convective, sloshing action of the waste.

To address this issue, it is recommended that the ANSYS analysis for the horizontally excited flexible tank with the 424-inch waste height be repeated using the following values for the coefficients α and β in the expression for the Rayleigh-form of damping.

$\alpha = 0.00930$ and $\beta = 0.00169$

These values correspond to a damping of 0.5 percent critical for the fundamental convective mode of 0.184 Hz, and of 4.0 percent critical for the fundamental impulsive mode of 7.5 Hz. The resulting solution should, of course, be compared with the corresponding theoretical solution.

It would also be desirable to assess the sensitivity of the ANSYS solutions to the approximations involved in the modeling of the waste as an incompressible, inviscid liquid. The relevant analyses should preferably be implemented for a flexible tank with an open top and a waste level of 424 inches.

Despite the fact that the ANSYS model for the tank considered in Ref. 4 does not adequately predict the slosh-height of the contained waste, it does predict reasonably the total hydrodynamic reactions and associated wall pressures, except, of course, for the pressures on a small segment of the tank wall around the waste surface that are dominated by the sloshing action. Shown in Table 1-2 and Fig. 5-11 of Ref. 4, the ANSYS results are overpredicted by less than 15 percent compared to their theoretical counterparts, the degree of overprediction being almost identical to that of the impulsive component of response referred to earlier.

For the tank with the 424-in waste height considered in this section, there is no indication from any of the solutions obtained that the sloshing waste will interact with the concrete dome at the top. It is relevant to note in this regard that the radial distribution of the maximum vertical surface displacements of the oscillating waste in the solution presented in Fig. 5-19 of Ref. 4 is in good agreement with the theoretical distribution for a tank with an open top. This is, of course, not true of the comparable solution shown in Fig. 4-18 of the same reference for a tank with the 460-in waste height.

In summary, the approach used in Ref. 4 to evaluate the seismic response of the primary tank with the 424-inch waste height is acceptable in our view. However, we still feel the need for the recommended additional studies to determine the reason or reasons for the severe overestimation of the surface sloshing action in the ANSYS solution.

3.2 Dytran Results for 422-inch Waste Level. For the indicated waste height, the results of the Dytran analyses for both rigid and flexible tanks are generally in very good agreement with the corresponding theoretical solutions, and better than those obtained with the ANSYS program. Satisfactory agreement was achieved for the fundamental natural frequencies of both the impulsive and convective modes, the maximum slosh-height, the total hydrodynamic reaction, as well as the magnitude and distribution of the associated wall pressures. The best agreement was achieved for Case 2c damping, which corresponds to a damping coefficient α = 2 and a damping factor of 1 percent critical for the fundamental convective mode

Apart from demonstrating the accuracy of the Dytran results for the conditions considered, the information presented also demonstrates the advantage of our preferred two-step approach that permits the use of different means for analyzing the components of the complex system involved in the present study.

3.3 Results for 460-inch Waste Level. If the waste in the tanks is raised to the 460-inch level, the concern is that the roof will partially suppress the surface sloshing action, reducing the portion of the waste mass that acts convectively and increasing the portion that acts impulsively. Considering that the natural frequencies of the impulsive modes are normally much higher than of the convective, the net effect of this constraining action would be an increase in the maximum values of the total hydrodynamic wall pressures and associated reactions over the values computed for the same tanks with an open top.

The portion of the waste mass being transformed from convective to impulsive, and the resulting increase in the overall response, clearly depend on the area of the roof being impacted by the sloshing waste. This area, in turn, depends on the available clearance between the waste surface and the roof. For a tank with a rigid, horizontal roof located immediately over the waste surface, the entire mass of the waste would respond in the impulsive mode, and the maximum values of the resulting hydrodynamic wall pressures and reactions would be significantly larger than those for an open-top tank.

Both the ANSYS and Dytran solutions for the maximum hydrodynamic pressures and reactions presented in Refs. 4 and 5 for the domed-tank with the 460-inch waste height are similar to the corresponding theoretical solutions obtained for a tank with an open top. If correct, these results would indicate that, for the waste level considered, the dome does not materially constrain the sloshing action of the waste, and that either program may also be used to evaluate the response of the tank with the 460-inch waste level. At this time, however, we are not convinced of the validity of this conclusion.

As already noted in Subsection 3.1, the ANSYS model does not accurately predict the surface sloshing action of the waste for an open-top tank. As a result, it is unlikely that it would accurately predict the constraining effect of the dome. It may be possible, however, to correct this deficiency by modifying the α and β parameters in the expression for the Rayleigh-form of damping, as suggested in Subsection 3.1. If this adjustment does lead to an acceptable solution for the tank with the 424-inch waste level, our confidence in the appropriateness of the ANSYS model for the FSI analysis of the tank with the 460-inch waste height will improve significantly.

Although of high accuracy for the tank with the 422-inch waste height, the results of the Dytran analyses for the 460-inch height also are suspect. In the solution displayed in Fig. 6-25 of Ref. 5, the waste around the tank periphery prior to the seismic excitation appears to have risen about 8 to 10 inches under gravity load. This obvious deficiency must be corrected before one can have confidence in the Dytran results. We suspect that a more refined mesh may be required to adequately model the waste in regions of potential interaction with the dome.

In summary, we feel that the effects of waste-roof interaction need to be further studied. In addition to the analyses with the indicated adjustments referred to above, it is recommended that

- Solutions be obtained for a flexible tank with a rigid, horizontal roof located at different distances above the waste surface; and that
- These solutions, along with those for the tank with the spherical dome, be compared with the predictions of the simple, approximate procedures described in Appendix D of Ref. 8 and in Ref. 9.

4. Forces Resisted by J-Bolts

The axial and shearing forces induced by the gravity and seismic loads at the interface of the concrete- and underlying steel-domes are resisted mainly by the interconnecting J-bolts. Both sets of forces, as shown in Figs. 6-36 and 6-41 of Ref. 3, are largest along the outermost ring of bolts. The maximum values of the tensile forces, T_b, and of the corresponding shearing forces, V_b, were determined to be

$$T_b = 2.61 \text{ kips/bolt} \quad \text{and} \quad V_b = 4.54 \text{ kips/bolt}$$

for the 'Upper Bound Soil – Best Estimate Concrete' case, and

$$T_b = 2.35 \text{ kips/bolt} \quad \text{and} \quad V_b = 5.40 \text{ kips/bolt}$$

for the 'Best Estimate Soil – Fully Cracked Concrete' case. These values are lower than the Abnormal (operating plus seismic) Load Allowables of

$$T_{bA} = 3.93 \text{ kips/bolt} \quad \text{and} \quad V_{bA} = 11.71 \text{ kips/bolt}$$

presented in Table 6-4 of Ref. 7.

Neither of us is familiar with the basis of the acceptance criteria for the reported allowables. Furthermore, we do not have sufficient information regarding the Nelson Internally Threaded Studs used to attach the J-bolts to the steel tank so that we may assess the appropriateness of the indicated allowables. However, we do question the accuracy of the reported demands.

The maximum forces in the bolts were computed on the assumption that the shear at the interface of the concrete and steel domes is resisted partly by friction, and a value of 0.4 was used for the coefficient of friction which is, of course, appropriate only for a non-sliding surface.

While we do agree that the frictional resistance at the interface of the two domes should not be ignored, considering that the seismic action is likely to induce at least some slippage at this interface, we feel that a lower value for the coefficient of friction than the one used would be more appropriate.

To gain some insight into the sensitivity of the results to the uncertainties involved in this issue, it is recommended that the analysis for the 'Best Estimate Soil – Fully Cracked Concrete' case, which leads to the maximum shear for the outermost ring of bolts, be repeated using the zero and 0.2 values for the coefficient of friction. In our judgement, the use of the sliding friction coefficient of 0.2 would be appropriate for the final solution.

In the J-bolt evaluation presented in Chapter 6 of Ref. 7, it appears that the shear forces considered were only those induced by the axial force in the wall of the primary tank. The analysis does not appear to have provided for the effect of the horizontal hydrodynamic reaction at the top of the primary tank, which is expected to the dominant contributor to the shear forces in the outermost ring of J-bolts. Unless we have misinterpreted the reported solutions, this deficiency must be corrected.

5. Buckling Evaluations

Reference 7 presents the results of a series of evaluations for the buckling of the primary tanks due to the axial forces induced by static and seismic effects, concrete creep, differential thermal expansion, and internal vacuum. Because of our lack of detailed familiarity with several of the analyses presented, and the fact that some of the reported results are not described in sufficient detail for an independent check, we comment on only a few of the issues addressed in this reference.

5.1 Local Bowing and Global Buckling. We concur that, as indicated in Fig. 3-5 of Ref. 7, the upper knuckle region of the tank is the critical region for the development of localized, radial bowing in the tank wall due to the combined effects of axial forces and internal vacuum. We further concur with the adequacy of the ASME reduced stiffness approach for determining the critical or limiting levels of these effects.

In evaluating the contribution of the seismic effects, however, it should be kept in mind that the axial force in the tank wall is not uniformly distributed over its height. It is unduly conservative, therefore, to use the maximum value of the axial force, which for the top-supported tank considered occurs near midheight, in evaluating the bowing action near the upper knuckle. Instead, the value in the region of the upper knuckle should be used.

As indicated in Figs. 3-11 through 3-13 of Ref. 7, global buckling of the primary tank cannot be induced by differential axial deformation between the tank and concrete vault. The compressive axial forces due to such deformation are self-limiting as a result of the local bowing action referred to above. Furthermore, as long as the J-bolts interconnecting the steel and concrete domes do not fail, the tank can displace axially only by an amount equal to the axial displacement of the concrete vault.

5.2 Elephant-Foot Buckling. Plastic elephant-foot buckling can occur only near the lower knuckle of the tank where, in addition to the compressive axial stresses, the circumferential tensile stresses are large and radial expansion is constrained by the base plate. This is the only location for which such buckling needs to be checked. The appropriate axial force for this evaluation is, of course, the force near the lower knuckle. As indicated in connection with the estimation of the bowing action in the upper knuckle region, it is unduly conservative to use the maximum value of the axial force which, for the top-supported tanks considered, occurs near midheight. Conversely, the seismically induced hoop stresses should not be reduced by the inelastic factor $F_\mu = 1.67$, because the hoop stresses continue to be in their elastic range at the onset of elephant-foot buckling.

We concur that elephant-foot buckling is not an issue for the tanks of interest. As long as the J-bolts interconnecting the steel and concrete domes do not fail and the tank is supported both laterally and vertically at the top and bottom, any localized bowing that may develop will relieve the axial force in the tank wall, and will prevent the bowing action from progressing to severe buckling.

The compressive axial force for the onset of elephant-foot buckling in Ref. 7 was determined by application of Eq. 7-1 in that reference, which is effectively an approximate, empirical equation. This force could also in that reference, have been determined by the method used to evaluate the localized bowing in the upper knuckle region. A relatively simple model, involving only the lower segment of the tank along with the appropriate conditions of support along its upper boundary, could have been used for this purpose.

6. A Concluding Comment

In the seismic analyses of the Hanford DSTs conducted so far – as in all previous analyses of waste-containing tanks that we are aware of – the waste was effectively modeled as a homogeneous, incompressible, practically inviscid liquid. As already noted in our earlier review (Ref. 1), there are fundamental uncertainties in this idealization, and it would be highly desirable to assess their effect on critical tank responses.

To this end, it was recommended that the ANSYS program be used to evaluate the response of a representative tank with the waste modeled more realistically as a deformable medium of low shearing resistance and finite energy dissipating capacity, and that a range of likely values be used for the latter properties. We conclude by repeating this recommendation, as the hydrodynamic effects for a tank storing a solid-like material may be materially larger than for a liquid-containing tank.

References

1. Kennedy, R.P. and A.S. Veletsos, *Comments and Recommendations Concerning Seismic Evaluation of Hanford Double-Shell Tanks,* Sept. 2005
2. Rinker, M.W., F.G. Abatt, B.G. Carpenter and C.A. Hendrix, *Hanford Double-Shell Tank Thermal and Seismic Project–Establishment of Methodology for Time Domain Soil-Structure Interaction Analysis of a Hanford Double-Shell Tank*, RPP-RPT-28964, Rev. 0, Pacific Northwest National Laboratory, Jan. 2006
3. Carpenter, B.G., C. Hendrix and F.G. Abatt, *ANSYS Seismic Analysis of Hanford Double-Shell Primary Tank, M&D-2008-004-*CALC-001, Rev. 0A, Draft, M&D Professional Services, Inc., Jan 2006
4. Rinker, M.W., B.G. Carpenter and F. G. Abatt, *Hanford Thermal and Seismic Project – ANSYS Benchmark Analysis of Seismically Induced Fluid-Structure Interaction in a Hanford Double-Shell Primary Tank,* RPP-RPT-28965, Rev. 0, Pacific Northwest National Laboratory, Jan 2006
5. Rinker, M.W. and F.G. Abatt, *Hanford Thermal and Seismic Project—Dytran Analysis of Seismically Induced Fluid-Structure Interaction on a Hanford Double-Shell Primary Tank,* RPP-RPT-28963, Rev. 0, Pacific Northwest National Laboratory, Jan. 2006
6. Rinker, M.W., et al., *Hanford Double-Shell Tank Thermal and Seismic Project-Summary of Combined Thermal and Operating Loads with Seismic Analysis,* RPP–RPT-xxxxx, Rev. 0, Jan. 2006
7. Johnson, K.I., et al., *Hanford Double-Shell Tank Thermal and Seismic Project—Buckling Evaluation Methods and Results for the Primary Tanks*, prepared for CH2M Hill Hanford Group, Feb. 2006
8. Bandyopadhyay, K. et al., *Seismic Design and Evaluation Guidelines for the Department of Energy High-Level Waste Storage Tanks and Appurtenances*, BNL 52361, Brookhaven National Laboratory, Upton, N.Y., Oct. 1995

9. Malhotra, P.K., *Sloshing Loads in Liquid-Storage Tanks with Insufficient Freeboard,* Earthquake Spectra, Vol. 23, No. 4, pp. 1185-1192, Nov. 2005.

B.2. Response to Fluid-Structure Interaction Analyses Comments

Additional analyses were conducted with the Dytran seismic model to address the issues raised by the reviewers on the fluid-structure interaction analyses. Results from these analyses are documented in a revision to the Dytran report RPP-RPT- 28963, Rev. 0A and in a new report, "Hanford Thermal and Seismic Project - Dytran Benchmark Analysis of Seismically Induced Fluid-Structure Interaction in Rigid Flat-Top Tanks", RPP-RPT-30807.

B.3. Discussion of J-bolt Evaluation Criteria

The primary tank is anchored to the concrete dome through uniformly spaced J-bolts. The J-bolts are threaded into Nelson Internal Threaded Studs welded to the primary tank dome in a uniformly spaced 2 by 2 ft. square pattern. Figure B.1 shows a typical installation. The Structural Evaluation Criteria document (Day et al 1995) specifies that the anchors be evaluated according to ASME Section III, Division 2, Subsection CC-3730 (ASME 1995). The reviewers indicated unfamiliarity with the bases of this criteria. This section examines the ASME J-bolt evaluation criteria with reference to other criteria.

The ASME allowable loads are limited to the lesser of 90% of anchor yield strength or 50% of anchor ultimate strength for mechanical loads. Subsection CC-3710 of ASME 1995 suggests that "testing of a prototype may be necessary" to verify the ultimate capacity of the J-bolt. Accordingly, Day et al (1995) specify the anchor ultimate strength in shear as the minimum of 90% of the anchor tensile strength or by the following equation (limited by the concrete strength) which is based on J-bolt testing:

$$F_u < 5.66\ A_s f'_c{}^{0.3} E_c{}^{0.44}$$

This equation is presented in the Nelson Stud Welding design document. Others, including AISC, have preferred to fit the experimental data with a slightly different form of the equation in order to maintain consistent units:

$$F_u < 0.5\ A_s f'_c{}^{0.5} E_c{}^{0.5}$$

Appendix B of ACI-349 also provides design requirements for anchors. A strength reduction factor of 0.75 is applied to shear loads. Both the steel strength of the anchor and the concrete breakout strength must be considered for shear loading. The basic breakout strength is:

$$V_b = 8(l/d_o)^{0.2}\sqrt{d_o}\sqrt{f'_c}\,c_1{}^{1.5}$$

The concrete strength is doubled for shear loads parallel to an edge. The continuous curved geometry of the DST structure eliminates any edges such that the controlling distance was taken to be ½ the distance between studs. For the DST reinforced concrete, the steel strength of the anchor becomes the governing criteria. Figure B.2 shows the different criteria. With the application of the appropriate factors, the allowable shear load being used for the DST analysis, 11,712 lbf is essentially identical to the ACI allowable of 11,928 lbf.

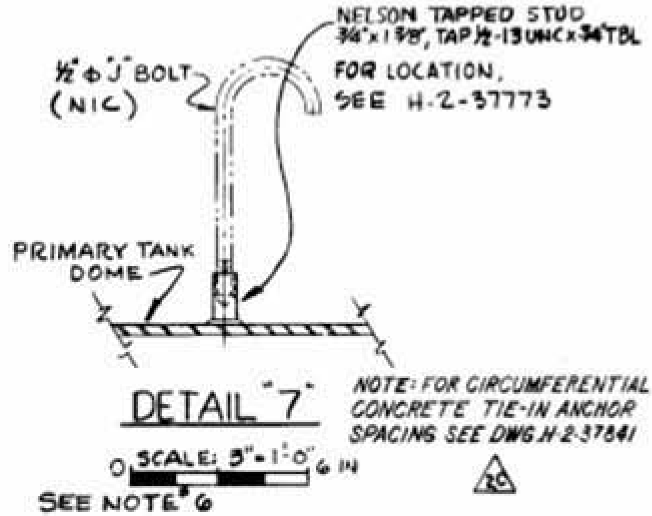


Figure B.1. J-Bolt Configuration

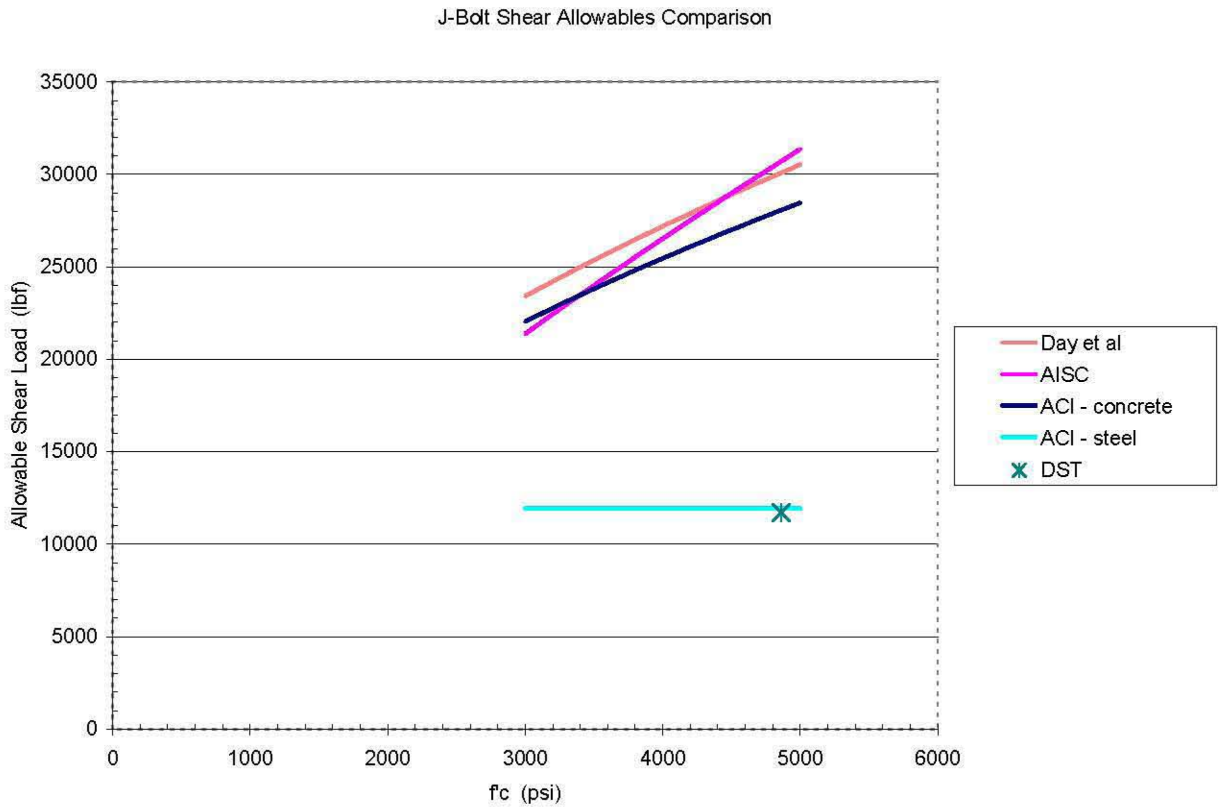


Figure B.2. J-Bolt Allowable Shear Force

B.4. Response to J-bolt/Dome Friction Evaluation Comments

The independent review questioned the use of a static coefficient of friction (COF) of 0.4 between the steel primary tank and the concrete dome. In order for the J-bolts to pick up shear load, slippage must occur between the concrete and steel tank. Such slippage is likely to reduce the COF to a sliding value, significantly less than 0.4. Accordingly, it was recommended that additional analyses with COF values of 0.0 and 0.2 be conducted with the underlying philosophy that a COF of 0.2 could be successfully defended if the results with COF=0.0 were problematic.

Preliminary simplified analyses with the seismic model suggested that a COF = 0.0 would give acceptable results. Consequently, both the seismic and TOLA analyses were repeated with COF = 0.0 for the Best Estimate Soil – Best Estimate Concrete material combination. The J-bolt results for the combined loads are shown in Figures B.1 and B.2. Small increases in the J-bolt demands are observed with the COF = 0.0 but the J-bolts are still well within the allowable limits. A complete description of the calculations conducted to address this issue is contained in Appendix C of this report.

B.5. Response to Buckling Evaluation Comments

Revisions were made to the buckling report, RPP-RPT-28967, Rev. 0A to incorporate the changes recommended by the reviewers to the buckling evaluation.

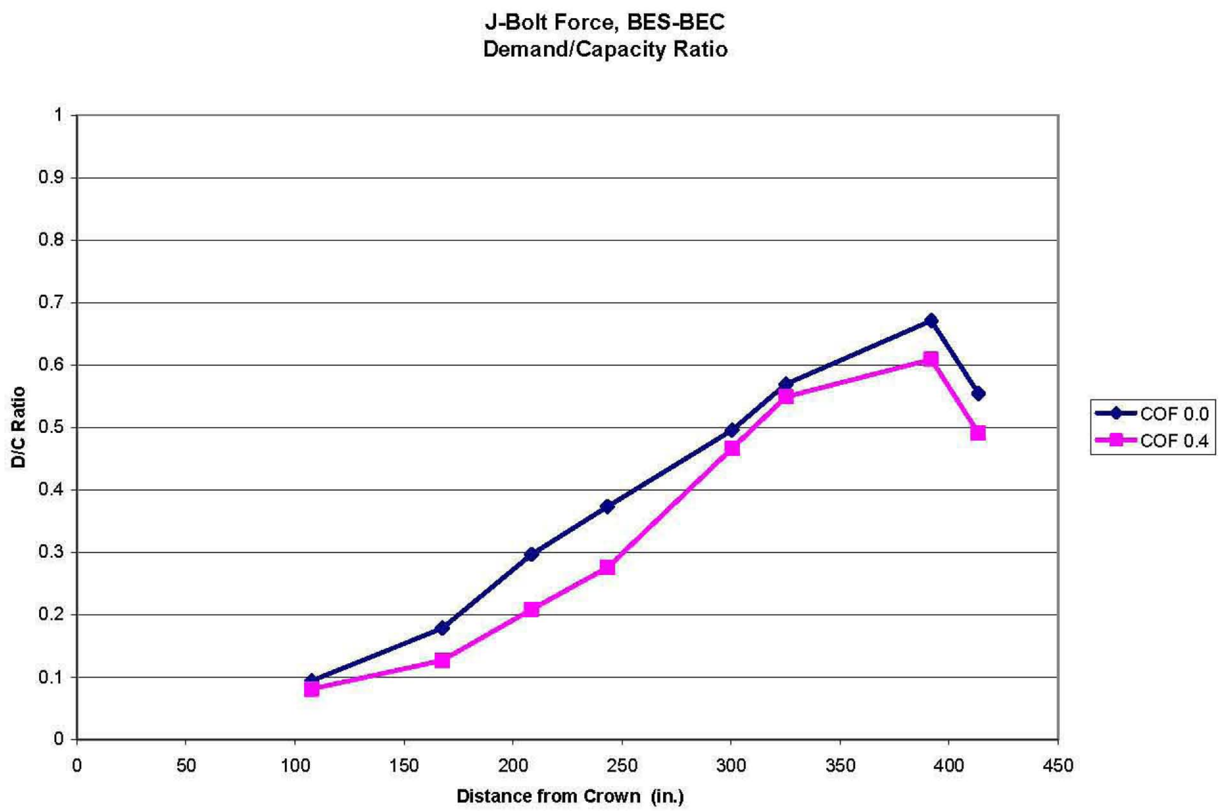
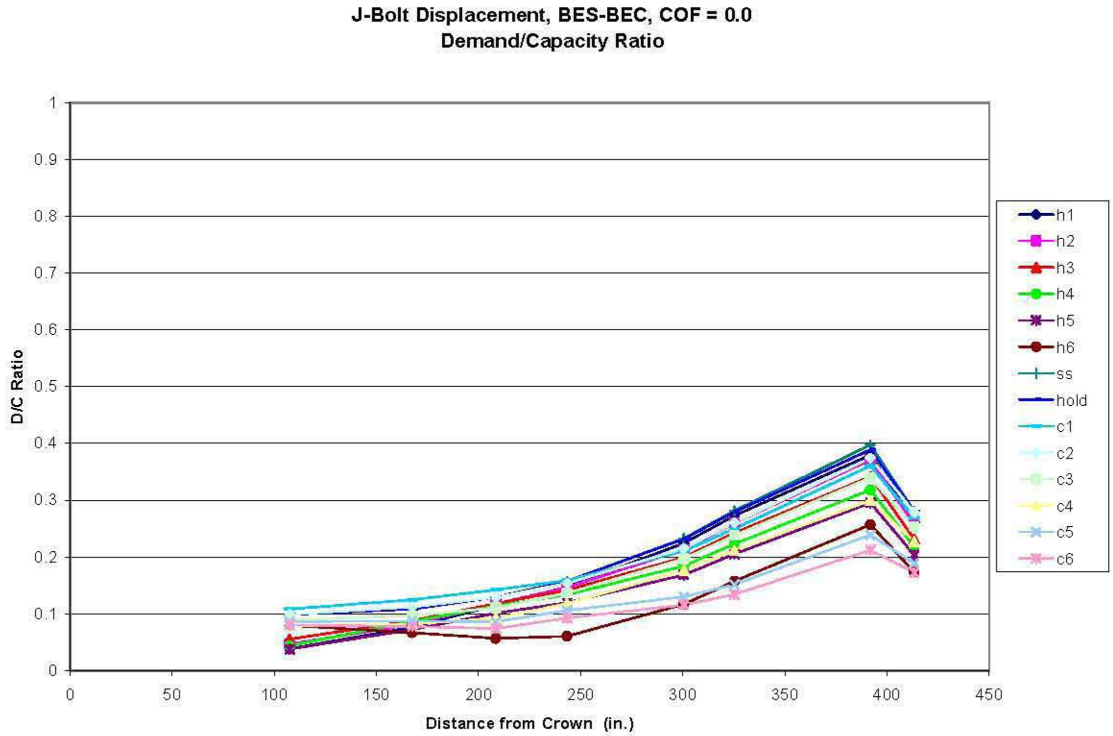


Figure B.3. J-Bolt Force Evaluation



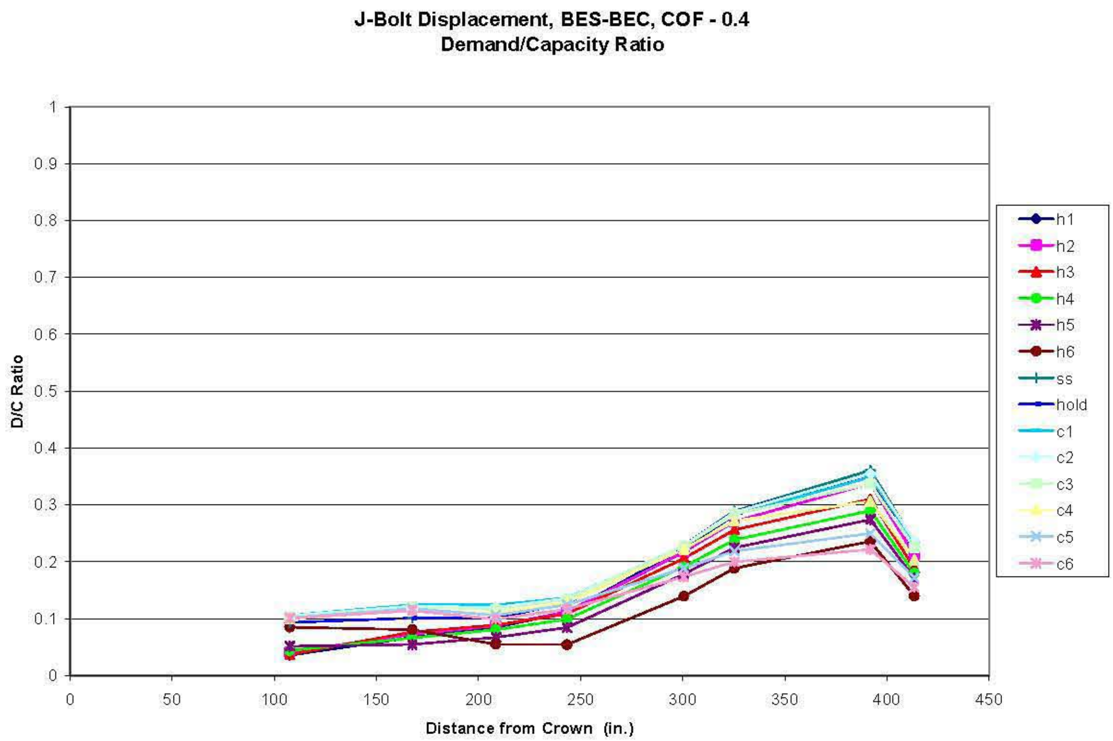


Figure B.4. J-Bolt Displacement Evaluation

B.6. Waste Modeling

Formal investigation of the uncertainty in the representation of the waste as an incompressible, homogeneous, inviscid fluid has not been addressed directly as it is considered out of scope for the current statement of work. However, the modeling of the waste in ANSYS is done using a deformable medium of low shearing resistance. Consequently, that model does provide some insight to the fluid-structure interaction response of the primary tank and waste system using this constitutive model of the waste.

B.6. Conclusion

Additional analyses to address the reviewers' comments have been conducted as required. The results of these analyses have not changed any of the conclusions of the Combined Thermal and Operating Loads with Seismic Analysis Report.

ANSYS® Seismic Analysis of Hanford Double Shell Tank, Dome Friction Study

B.G. Carpenter
C. Hendrix
F.G. Abatt

January 2007

Prepared by
M&D Professional Services, Inc.
for
Pacific Northwest National Laboratory

M&D Professional Services		Page: ii
		Document No.: M&D-2008-004-CALC-02
		Revision No.: 0
		Total Pages: 154

PROJECT NAME:	PROJECT NUMBER:	CLIENT:
DST Seismic Analysis	2008-006	PNNL

TITLE:

ANSYS® Seismic Analysis of Hanford Double Shell Tank, Dome Friction Study

PROBLEM STATEMENT:

Evaluate the Influence of Friction in Parallel with Dome J-bolts

ANALYTICAL SOFTWARE USED:	PROGRAM/PACKAGE	VERSION	UNVERIFIED ASSUMPTIONS
Yes ___X___ No ______	ANSYS®	8.1	Yes __ __ No __X__

REV.	AFFECTED PAGES	REVISION DESCRIPTION	PREPARER(S)/ DATE	CHECKER(S)/ DATE	APPROVER/ DATE
A	All	Original Issue	Bruce Carpenter	Chad Hendrix	F.G. Abatt

Executive Summary

This work was performed in support of a project entitled *Double-Shell Tank (DST) Integrity Project-DST Thermal and Seismic Analysis.* The analysis is directly related to work reported in Rinker et al. (2006a) and Rinker, et al. (2006b) and was motivated by recommendations from a Project Review held on March 20-21, 2006 (Appendix E of Rinker et al. 2006b).

One of the recommendations was to repeat a tank analysis using coefficients of friction of zero and 0.2 and to evaluate the influence of friction on the dome and J-bolt loads. In order to minimize the number of time history analyses required, a static load study was performed to enable selection of one coefficient of friction to use for a full time history analysis.

This calculation provides the results from a study of the influence of the coefficient of friction between the primary tank and concrete tank in conjunction with explicitly modeling the J-bolts. Reviewers noted that friction and J-bolt elements have incompatible shear stiffnesses and including both load paths is not compatible with most code requirements. Multiple load cases were considered and coefficients of friction between 0.4 and 0.0 were evaluated. Based on the results of these load cases it was determined that a coefficient of friction of 0.0 should be used and would result in only marginal changes in the resulting forces on the J-bolts.

Limited attempts were made to model the dome interface eliminating the J-bolts and retaining a coefficient of friction of 0.4 for the contact surface modeled. Mathematically stable initial conditions could not be obtained without including J-bolts in the model. Therefore, this path of testing was stopped.

An additional full time history was performed using the Best Estimate Soil, Best Estimate Concrete case, but with zero friction in the concrete dome/primary tank interface. Removing the friction between the primary tank and concrete for the full transient analysis decreased the seismic axial force and increased the shear forces on the J-bolts by -3% and +13% respectively

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LIST OF FIGURES

Acronyms and Abbreviations

BEC	Best Estimate Concrete
BES	Best Estimate Soil
DST	Double Shell Tank
g	Acceleration of Gravity
M&D	M&D Professional Services, Inc
PNNL	Pacific Northwest National Laboratory
psi	Pound per Square Inch

1.0 INTRODUCTION

This work was performed in support of a project entitled *Double-Shell Tank(DST) Integrity Project-DST Thermal and Seismic Analysis*. The analysis is directly related to work reported in Rinker et al. (2006a) and Rinker, et al. (2006b) and was motivated by recommendations from a Project Review held on March 20-21, 2006 (Appendix E of Rinker et al. 2006b).

The reviewers noted that a frictional coefficient of 0.4 used in the original analysis reported in Rinker et al. (2006a) is likely too high if any slipping was to occur at the interface, and that a frictional coefficient of 0.2 is more appropriate. The reviewers suggested that use a frictional coefficient of 0.4 while also crediting the J-bolts for shear capacity may result in unrealistically low demands on the J-bolts. To gain insight into the sensitivity of the results to the uncertainties, it was recommended that the analysis be repeated using frictional coefficients of zero and 0.2, with the value of 0.2 being judged acceptable for the final solution.

This calculation documents the sensitivity of J-bolt loads to the frictional coefficient between the primary tank and concrete dome. Evaluating the influence of the friction was done in two steps:

1) Perform a series of static analyses as the basis for selecting a coefficient of friction
2) Perform an additional transient analysis using a new coefficient of friction.

Additional work was performed to remove the J-bolts from the model to determine if all the shear loads between the primary tank and concrete dome could be carried by friction. Removal of the J-bolts proved to not be a feasible approach because it introduced numerical instabilities in the model.

Although the reviewers recommended the Best Estimate Soil, Fully Cracked Concrete case as the baseline case, the Best Estimate Soil, Best Estimate Concrete load case was selected from Rinker, et al. (2006c) to be rerun with a reduced coefficient of friction. The choice of baseline case was made for convenience and is expected to not have any effect on the conclusions of the study.

1.1 DISCUSSION

The purpose of the calculation is to document the influence of J-bolts and friction in the interface between the primary tank and the concrete dome. Reviewers noted that friction and J-bolt elements have incompatible shear stiffnesses. Before the J-bolts can pick up much shear, slippage must occur between the concrete and primary tank. A couple of cycles of slippage will likely reduce the sliding coefficient of friction. It was also noted that most design codes do not allow crediting friction when evaluating anchorages.

Based on these reviewer comments, this study was undertaken to evaluate the influence of friction between the primary tank and concrete dome. The model representing the best estimate soil and best estimate concrete was taken from Rinker, et al. (2006c) and modified for this study (referred to as the "baseline model"). Minimal changes were made to the baseline model to ensure that only the contribution of dome friction was addressed. The baseline model used a coefficient of friction of 0.4.

The impact of the changes in friction is limited to the dome region of the DST. Therefore, instead of evaluating all the results, only the J-bolt forces, dome contact results, primary tank stresses and concrete forces and moments were extracted and compared.

1.2 CONCLUSIONS

It was demonstrated that the J-bolt forces are insensitive to the value of the frictional coefficient for the range of values considered, and that the loads in the J-bolts are acceptable if the interface between the primary tank and concrete dome is modeled as frictionless.

The dome and J-bolt interface cannot be modeled without the inclusion of the J-bolts due to the introduction of numerical instabilities into the model. Various unsuccessful model modifications were made to represent the dome interface not using any J-bolts. Because of the significantly different stiffnesses of the concrete shell and primary tank shell, an acceptable initial condition could not be obtained, i.e., the two shells could not be made to act together but behaved as independent structures. Because the reduction of friction on the contact surface proved successful, the effort to remove the J-bolts was stopped.

Under the transient loading, frictional forces between the dome and the primary tank are redistributed to the J-bolts in shear, but in a much more uniform fashion. While the increase in shear forces in the J-bolts occurred such that the maximum shear force increased, it also occurs throughout the majority of the dome.

Removing the friction between the primary tank and concrete for the full transient analysis decreased the seismic axial force and increased the shear forces on the J-bolts by -3% and +13% respectively.

	μ=0.4 (kip)	μ=0 (kip)	Allowable Forces (kip)
Axial	2.246	2.176	3.73
Shear	4.052	4.591	11.71

The decrease in the total axial loads is because the decrease in axial force under gravity only (0.43 kip vs 0.12 kip) outweighs the increase due to seismic (1.81 kip vs 2.06 kip).

An increase of the same magnitude in the J-bolt shear for the Best Estimate Soil, Fully Cracked Concrete initially recommended as the baseline case results in a shear force of 6.10 kip, which is stll well below the allowable shear force of 11.71 kip.

2.0 METHODOLOGY

2.1 MODEL DEVELOPMENT

A detailed description of the model used in this study can be found in Rinker, et al. (2006c). For this study, the only modifications to the model as described are the coefficient of friction between the primary tank and concrete dome, and the normal contact stiffness factor.

2.2 FRICTION STUDY

To evaluate the influence of friction on the behavior of the interface between the primary tank and the concrete dome, a simple study was performed prior to running a full time history analyis. This simple study allows selection of a coefficient of friction for a single time history. A series of cases were run with a small (0.05*g*) constant lateral force applied, but varying the coefficient of friction in the contact elements. Results were extracted for the J-bolts, primary tank/concrete dome contact elements, concrete, and primary tank. By comparing the results of the different load cases, the effect of friction on the load path can be evaluated. The cases are as follows (the "L" indicates the lateral force of 0.05*g* was included):

- μ=0.4-L
- μ=0.3-L
- μ=0.2-L
- μ=0.1-L
- μ=0.0-L

Friction coefficients covering the range between 0 and 0.4 were considered to capture where any abrupt change in behavior (load carried by friction vs J-bolts) might occur. Each friction case was run for a total of 10 time steps, or a total of 0.1 seconds. A short transient run was performed for each case to make the post-processing of results the same as for the full time histories.

2.3 TIME HISTORY

After completion of the friction study a coefficient of friction of 0.0 was selected and a full time history was performed using the Best Estimate Soil, Best Estimate Concrete case. The Best Estimate Soil, Best Estimate Concrete case was selected in lieu of the Best Estimate Soil, Fully Cracked Concrete because the Best Estimate Concrete case is considered as the nominal base case from which other comparisons are made. Results extracted for the full transient analysis were then compared to the baseline case (Best Estimate Soil, Best Estimate Concrete, with a coefficient of friction of 0.4).

3.0 MODEL DESCRIPTION

Two parameters were modified from the baseline analytical model for this study, the coefficient of friction between the primary tank and concrete dome (μ for material type 700, file: Bolts-Friction.txt), and the contact stiffness (FKN, for real 701 through 711, file: Bolts-Friction.txt). The coefficient of friction was varied between 0.4 (original value used) to 0.0, in 0.1 increments. Note that a value of 0.001 for μ was used for the "0.0" case to aid in solution stability. The value of FKN was reduced from 0.1 to 0.025 to reduce "chatter" in the related contact elements.

Figure 3-1 and Figure 3-2 show the region of the ANSYS model that includes both J-bolts and contact surfaces. In Figure 3-1, the thick shell elements represent the concrete shell, the thin shell elements represent the primary tank, and the square elements represent the beam elements used for the J-bolts. In Figure 3-2, the target surface is the top continuous surface (representing the inside face of the concrete), the contact surface is the inside surface (representing the outside face of the primary tank), and the J-bolts are again shown as the square elements connecting the two surfaces. The target and contact surfaces are shown separated because their geometry is based on the geometry of the concrete and primary tank. Key Options for the contact elements are used to define the interface surface accounting for the thickness of the elements used to generate the surfaces.

Figure 3-1. ANSYS Model – Concrete Tank, Primary Tank and J-bolt Elements

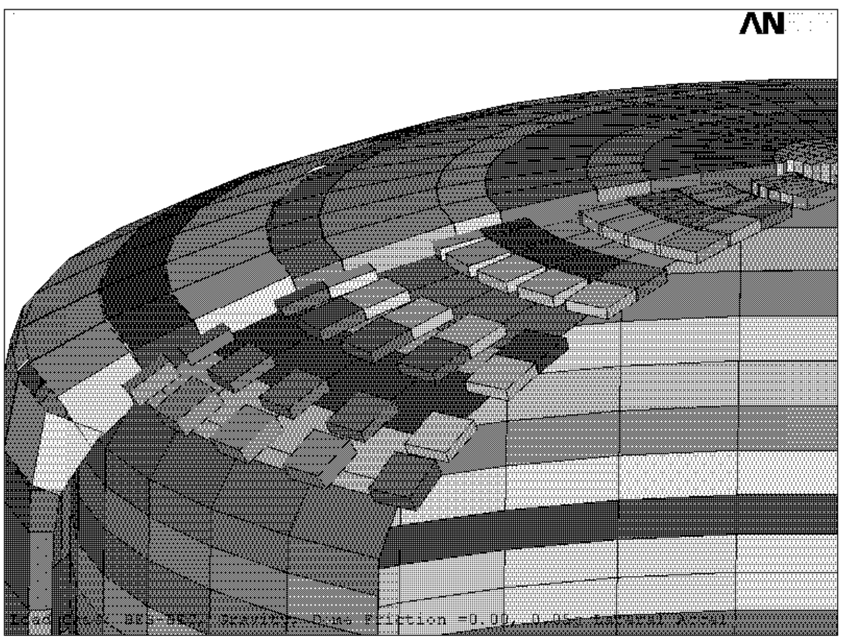
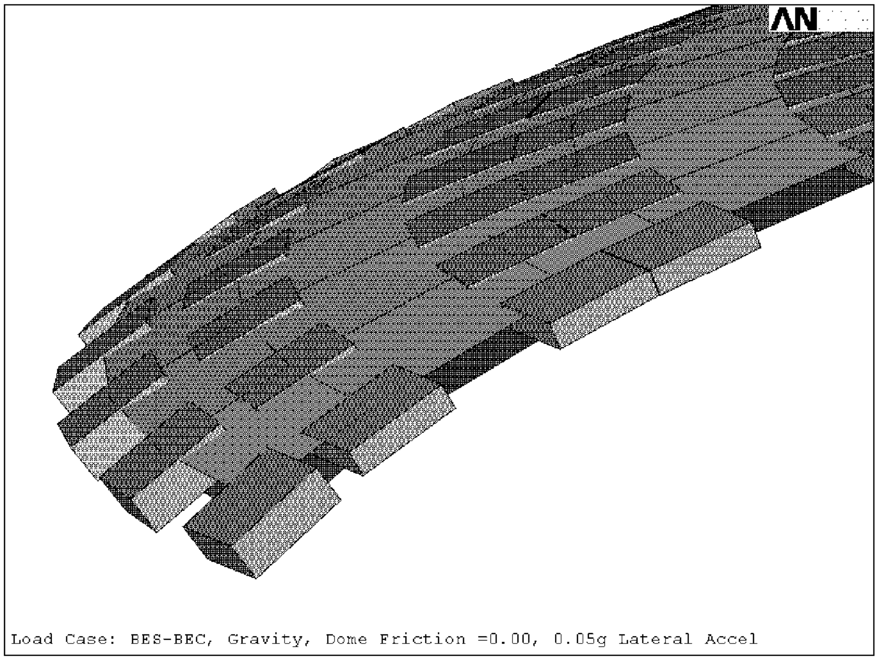


Figure 3-2. ANSYS Model, J-bolt and Contact Elements



4.0 STUDIES

4.1 FRICTION STUDY

To get an understanding of the influence of the dome coefficient of friction on the J-bolt loads, a series of static analyses were performed with a 0.05*g* lateral force, using five different coefficients of friction. A lateral acceleration of 0.05*g* is an arbitrary value, but allows for comparison using a common loading condition. The analyses were not just a static analysis, but a transient analysis consisting of 10 time steps, while maintaining a constant load. Results were extracted for the J-bolts, dome contacts, primary tank stresses and concrete forces and moments and normalized to the maximum value for each component. After comparisons of the different components, a nominal coefficient of friction of zero (0.001) was selected for an additional full time history analysis.

Figure 4-1 through Figure 4-3 show a comparison of J-bolt axial and shear forces for the range of coefficients of friction considered. Bolt forces are plotted against the radius at which the bolts are modeled, starting at zero at the dome apex, increasing to approximately 400 inches, which has been defined as the "path" on the X-axis. The J-bolts near the center of the dome and near the outside radius of the dome show essentially no change in axial or shear forces. An increase in shear force between 60 and 80 lbf/bolt occurs between the maximum friction and zero friction. At the outside ring of J-bolts, the magnitude of the shear increase is the same (67 lbf), but is less than 4% of the total shear. Where the highest axial forces occur (outside ring), there is essentially no change in axial force as a function of dome friction. Therefore, a coefficient of friction of zero is expected to have only a marginal affect on the results for a full transient analysis.

Figure 4-1. Maximum J-bolts Axial Forces, 0.05g Lateral Force

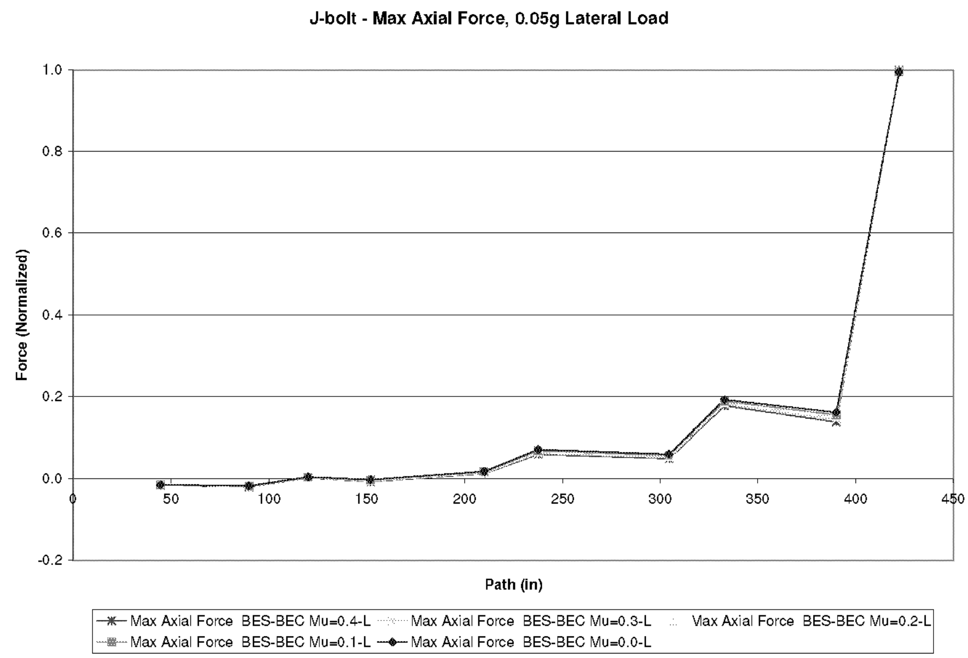


Figure 4-2. Minimum J-bolts Axial Forces, 0.05g Lateral Force

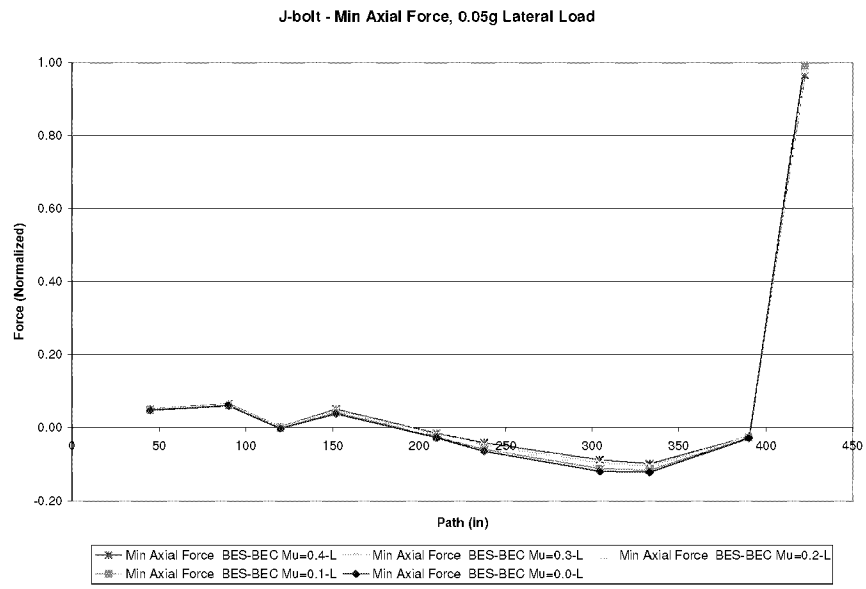


Figure 4-3. Maximum J-bolts Shear Forces, 0.05g Lateral Force

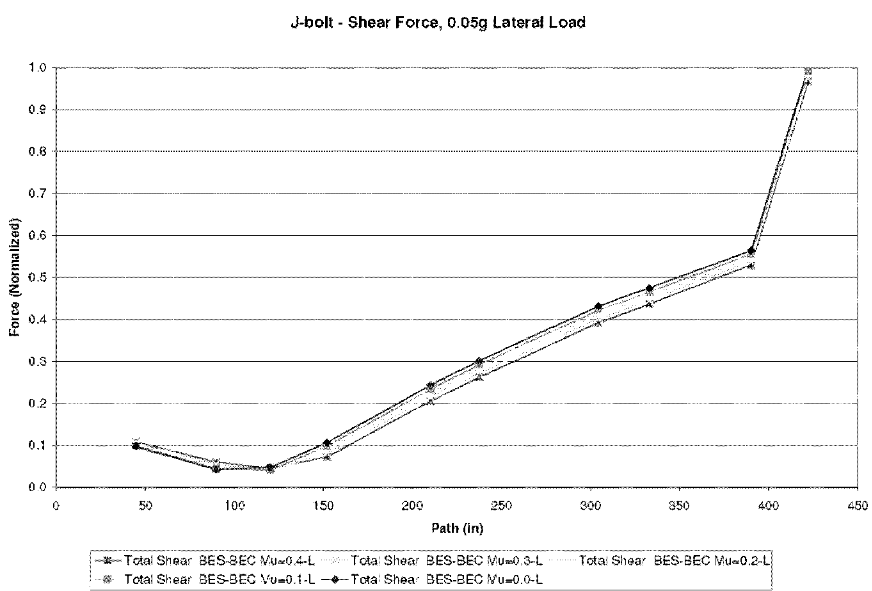


Figure 4-4 through Figure 4-6 show a comparison of the dome contact pressures and shear friction. Other than near the center of the dome, there is essentially no change in contact normal forces. The shear friction forces are directly proportional to the coefficient of friction. Because the contact normal forces are insensitive to the dome coefficient of friction, a value of zero is expected to have a small effect on the full transient analysis.

Figure 4-4. Maximum Dome Contact Pressures, 0.05g Lateral Force

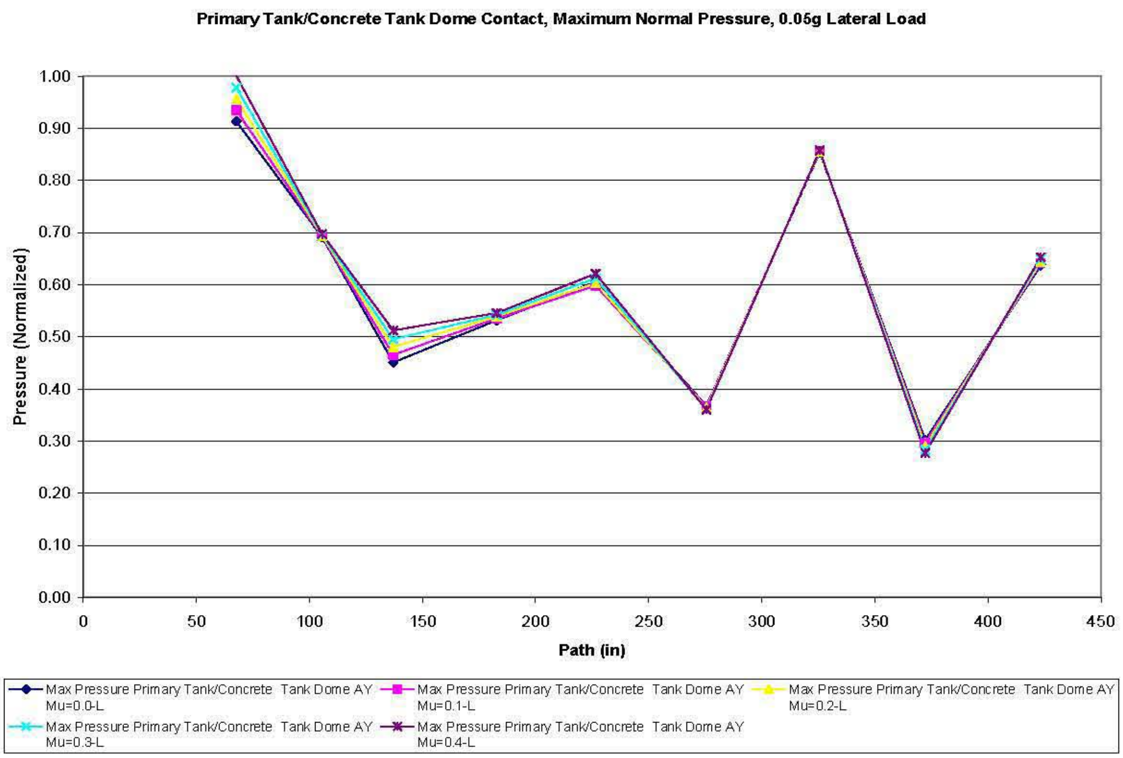


Figure 4-5. Minimum Dome Contact Pressures, 0.05g Lateral Force

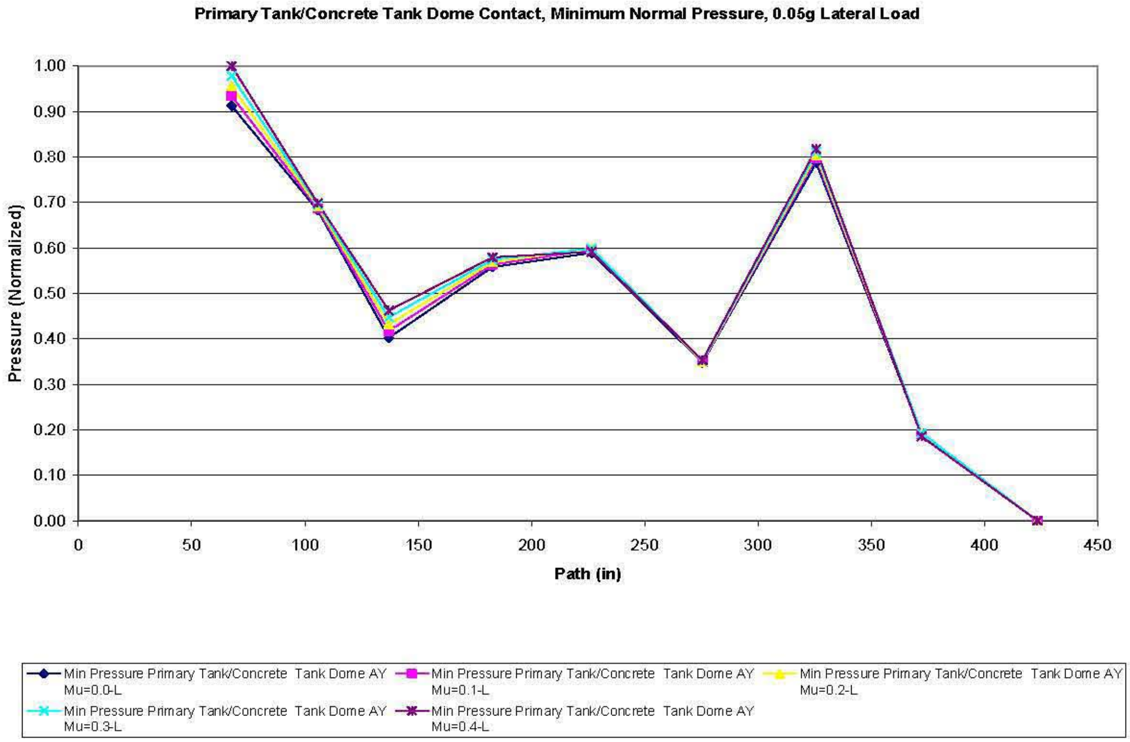


Figure 4-6. Maximum Dome Contact Friction Force, 0.05g Lateral Force

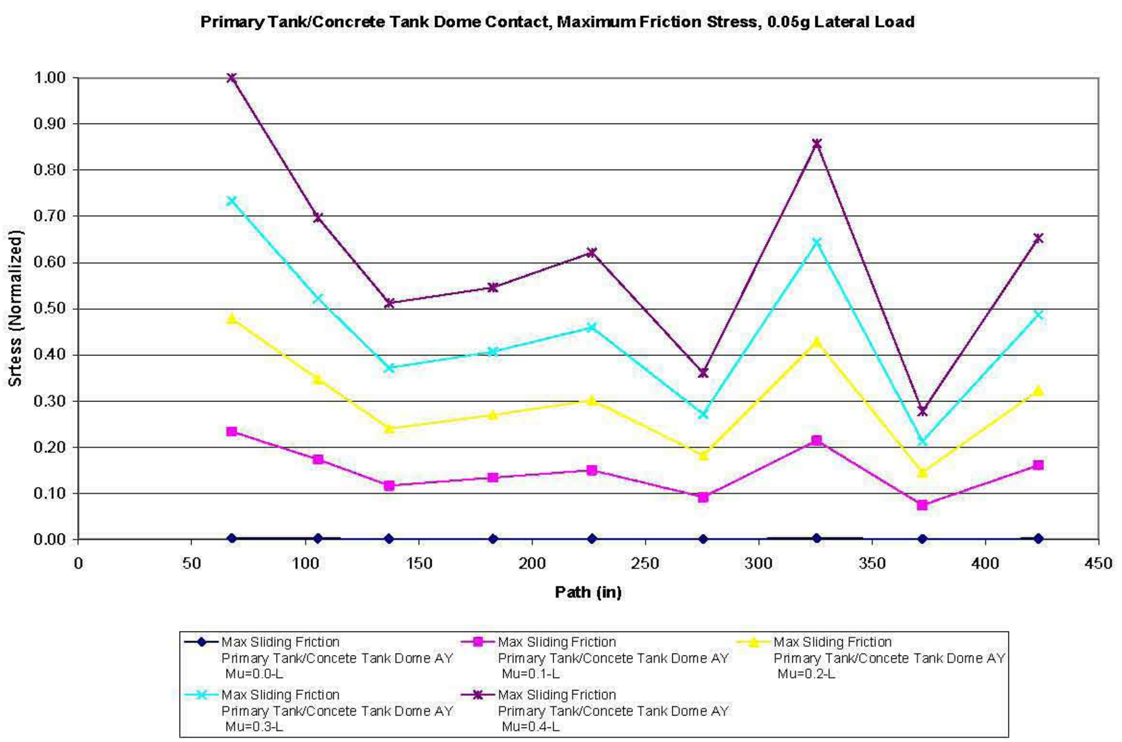


Figure 4-7 through Figure 4-12 show the changes in concrete forces and primary tank stresses for selected components only for just the extreme values of friction (0.0 and 0.4). The changes in forces and stresses are small compared to the total magnitude of the loads. Therefore, a coefficient of friction of zero is expected to have a small impact on the full transient analysis.

Figure 4-7. Maximum Concrete Dome Hoop Forces, 0.05g Lateral Force

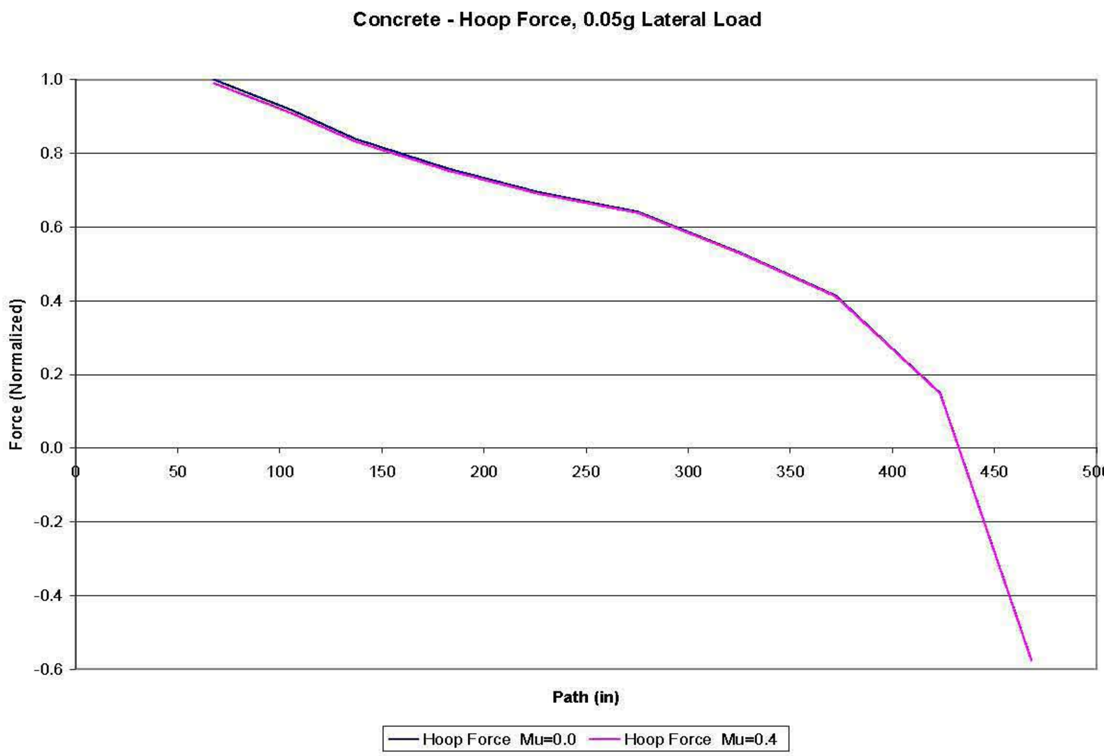


Figure 4-8. Maximum Concrete Dome Meridional Forces, 0.05g Lateral Force

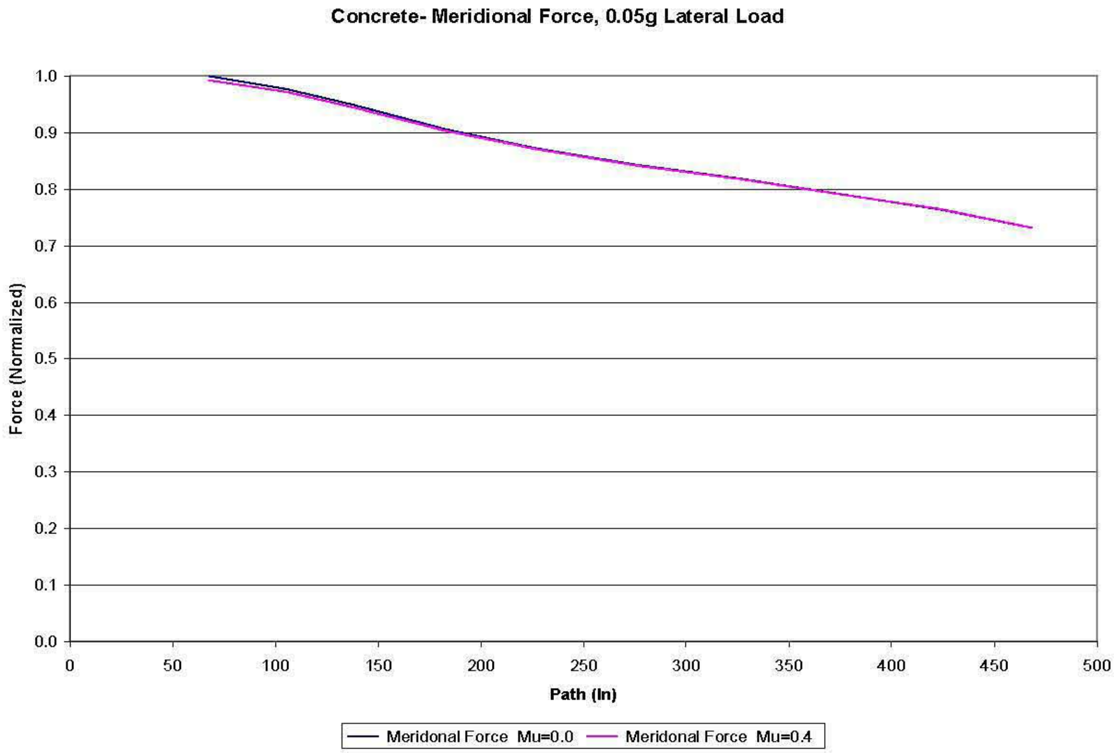


Figure 4-9. Maximum Concrete Dome In-Plane Shear Forces, 0.05g Lateral Force

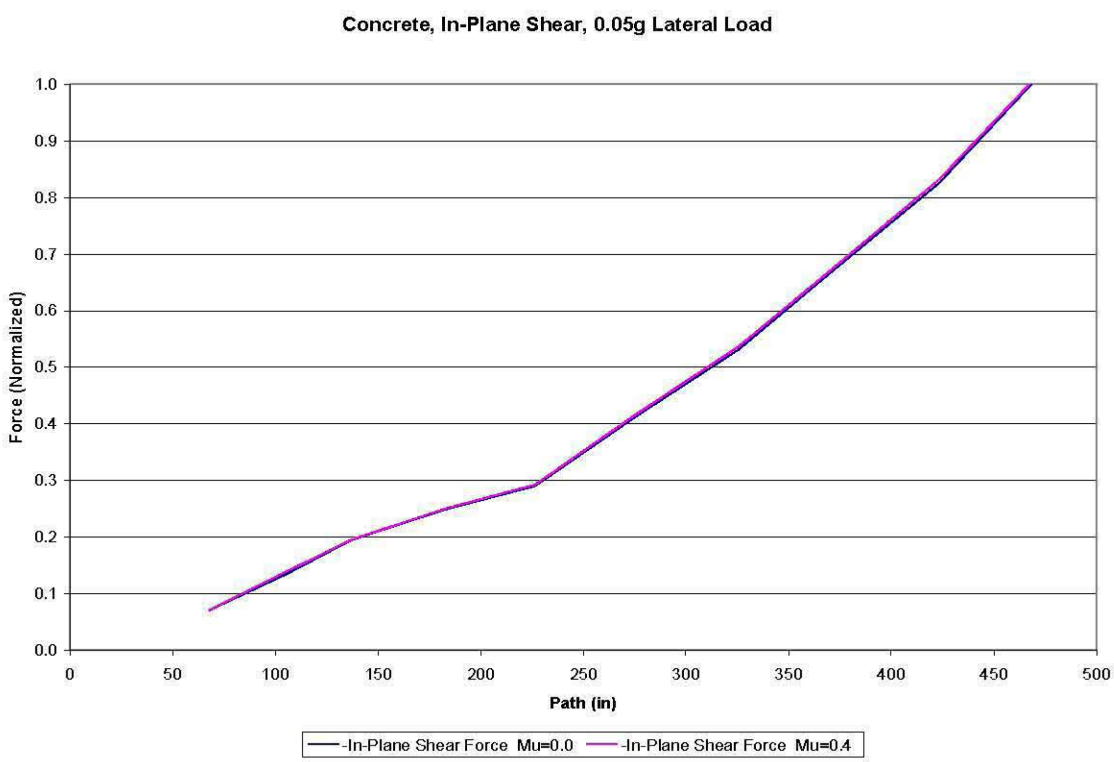


Figure 4-10. Maximum Primary Tank Dome Hoop Stresses, Shell Mid-Plane, 0.05g Lateral Force

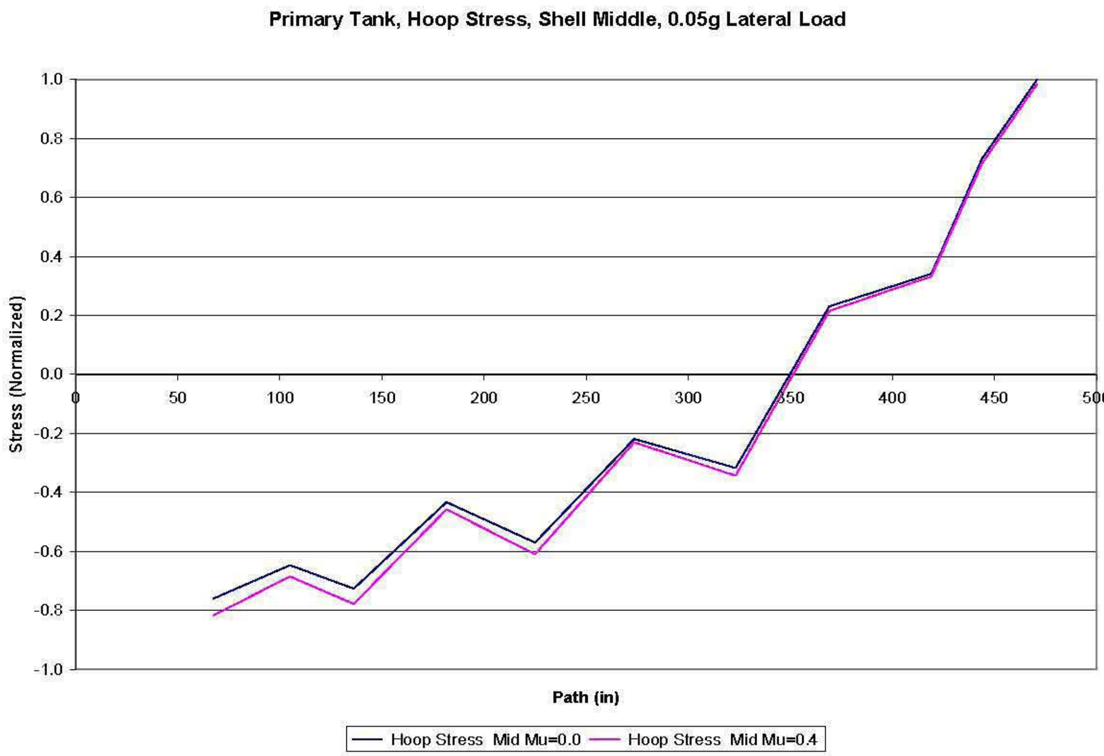


Figure 4-11. Maximum Primary Tank Dome Meridional Stresses, Shell Mid-Plane, 0.05g Lateral Force

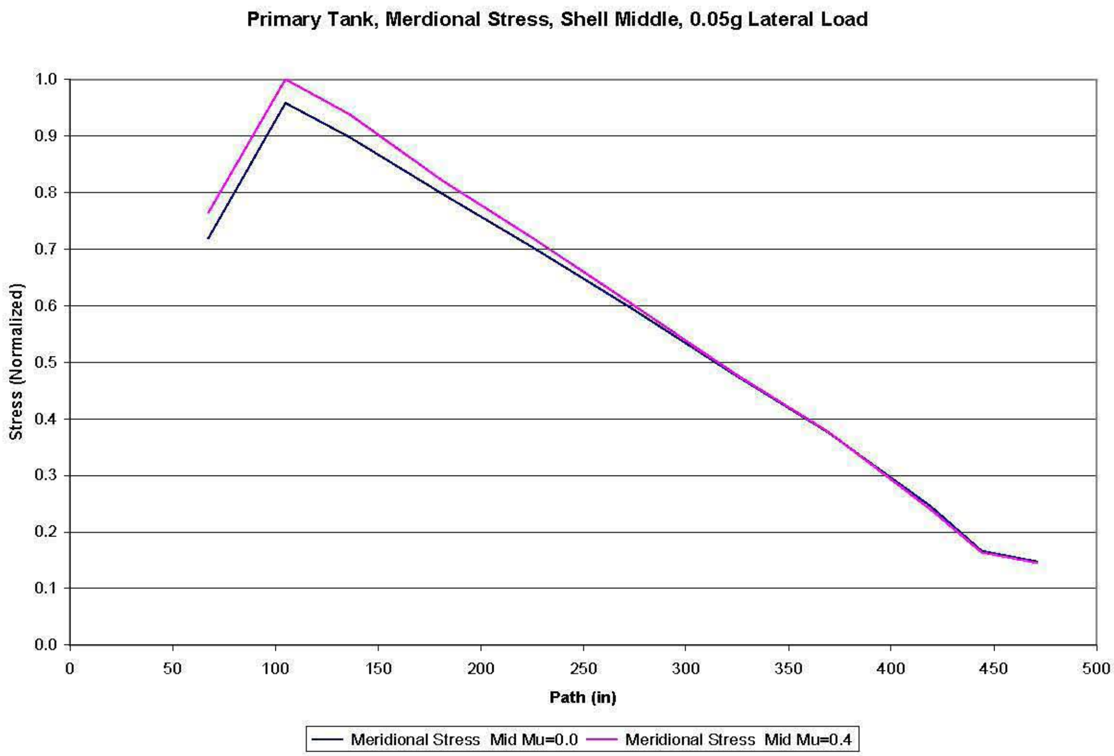
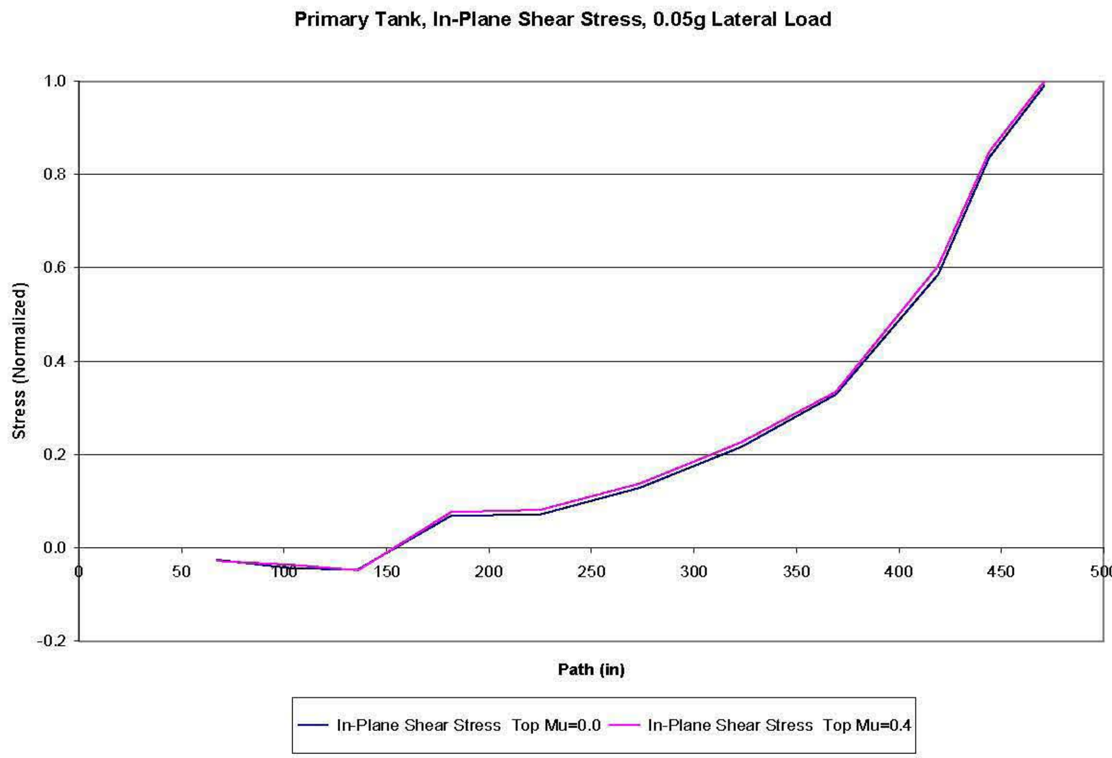


Figure 4-12. Maximum Primary Tank Dome In-Plane Shear Stresses, Shell Top, 0.05g Lateral Force



4.2 CONTACT STIFFNESS

During the evaluation of the static results of the friction study, contact chatter was identified. The contact pressures fluctuated over the time steps, but were not caused by a varying load (this is called contact chatter, high frequency changes in contact pressures or status during or between time steps). Based on this chatter, the value of FKN (normal contact stiffness factor) was reduced from 0.1 to 0.025. Figure 4-13 shows the contact normal pressure for the first 10 seconds of the transient analysis for element No. 8237, from Rinker, et al. (2006c). There is significant chatter in the first few seconds. Figure 4-14 shows the contact normal pressure for the same element, but with the value of FKN reduced to 0.025. The contact pressure is fairly constant during the three seconds before seismic excitation starts. The results for element no. 8237 are shown as a representative case for the effect of modifying FKN.

Figure 4-13. Element 8237 Contact Pressure, FKN = 0.1

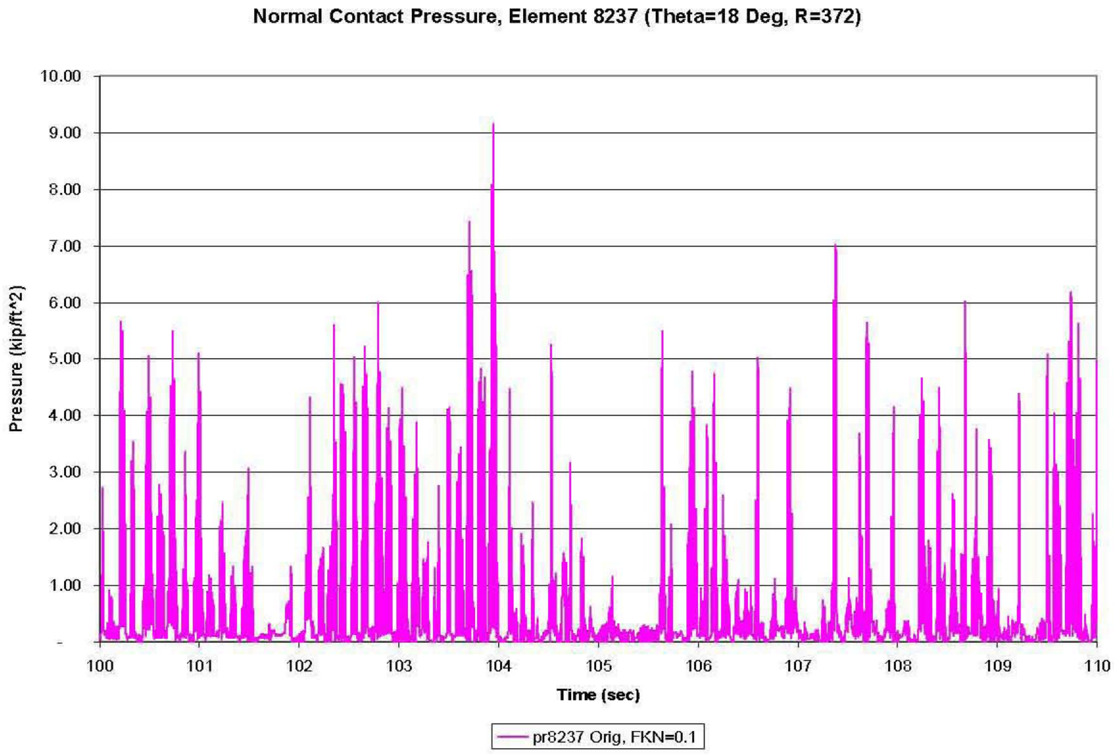
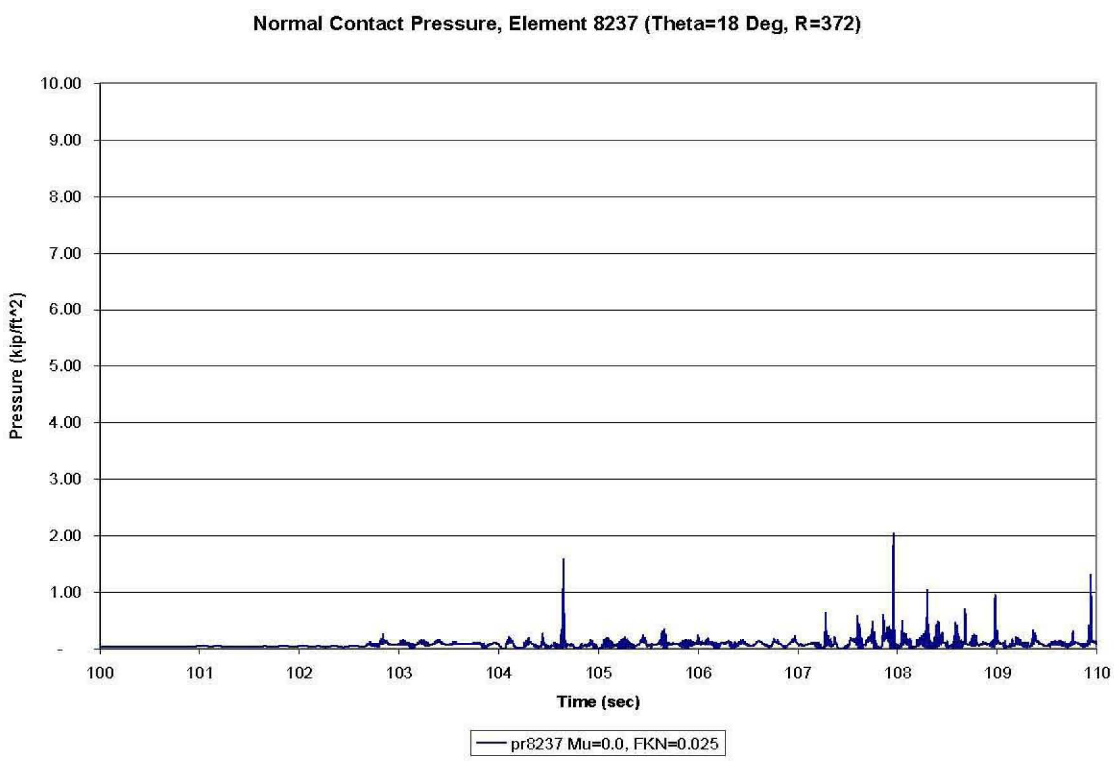


Figure 4-14. Element 8237 Contact Pressure, FKN = 0.025



5.0 TANK RESULTS

5.1 CONCRETE TANK

Concrete tank forces and moments are extracted from the model in 9 degree slices, starting near the top of the dome and moving down the wall and across the footing from the outside to the center of the tank. Figure 5-1 show the first slice, with element numbers. Each of the subsequent figures shows one component of force or moment, comparing the results from the μ=0 and μ=0.4 load cases. The results presented for the concrete forces and moments are enveloped minima/maxima around the circumference of the tank.

The following forces/moments for SHELL143 elements were extracted from the model

- SMISC1 Hoop force (Meridional in footing)
- SMISC2 Meridional force (Hoop in footing)
- SMISC3 In-Plane shear force
- SMISC4 Hoop Moment (Meridional in footing)
- SMISC5 Meridional Moment (Hoop in footing)
- SMISC6 Twisting Moment
- SMISC7 Through Wall Shear Force (XZ)
- SMISC8 Through Wall Shear Force (YZ)

Figures are grouped in sets showing the force or moment for gravity loading only first, total demand from the transient analysis (gravity plus seismic), and then only the seismic portion. The seismic load is simply the difference between the full transient loading and gravity loading only. The forces and moments are plotted against a "path" which starts at 0 at the top of the dome, increasing to the center of the footing. Only the region from the dome apex through the haunch is shown for this study. Forces and moment have been enveloped circumferentially for these plots. Concrete force/moment plots are as follows:

- Figure 5-2. Concrete Tank Hoop Forces – Gravity Only
- Figure 5-3. Concrete Tank Hoop Forces – Gravity Plus Seismic
- Figure 5-4. Concrete Tank Hoop Forces – Seismic Only
- Figure 5-5. Concrete Tank Meridional Forces – Gravity Only
- Figure 5-6. Concrete Tank Meridional Forces – Gravity Plus Seismic
- Figure 5-7. Concrete Tank Meridional Forces – Seismic Only
- Figure 5-8. Concrete Tank Hoop Moments – Gravity Only
- Figure 5-9. Concrete Tank Hoop Moments – Gravity Plus Seismic
- Figure 5-10. Concrete Tank Hoop Moments – Seismic Only
- Figure 5-11. Concrete Tank Meridional Moments – Gravity Only
- Figure 5-12. Concrete Tank Meridional Moments – Gravity Plus Seismic
- Figure 5-13. Concrete Tank Meridional Moment– Seismic Only
- Figure 5-14. Concrete Tank In-Plane Shear Forces – Gravity Only
- Figure 5-15. Concrete Tank In-Plane Shear Forces – Gravity Plus Seismic
- Figure 5-16. Concrete Tank In-Plane Shear Forces – Seismic Only

- Figure 5-17. Concrete Tank Through-Wall Shear Forces – Gravity Only
- Figure 5-18. Concrete Tank Through-Wall Shear Forces – Gravity Plus Seismic
- Figure 5-19. Concrete Tank Through-Wall Shear Forces – Seismic Only

Results for through wall shear forces are the envelope of SMISC7 and SMISC8. No results are presented for SMISC6, the element XY moment.

Figure 5-1. Concrete Tank Element Retreival Sequence Starting Numbers

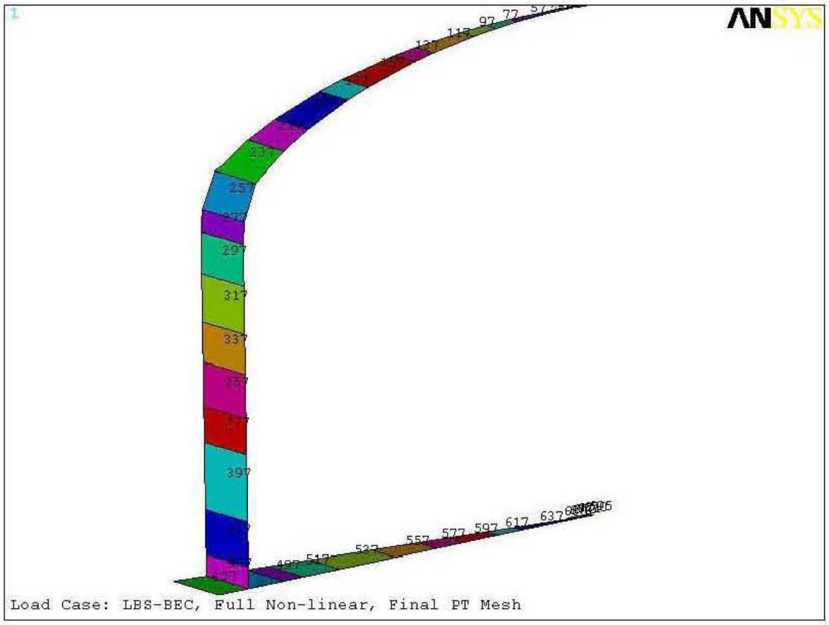


Figure 5-2. Concrete Tank Hoop Forces – Gravity Only

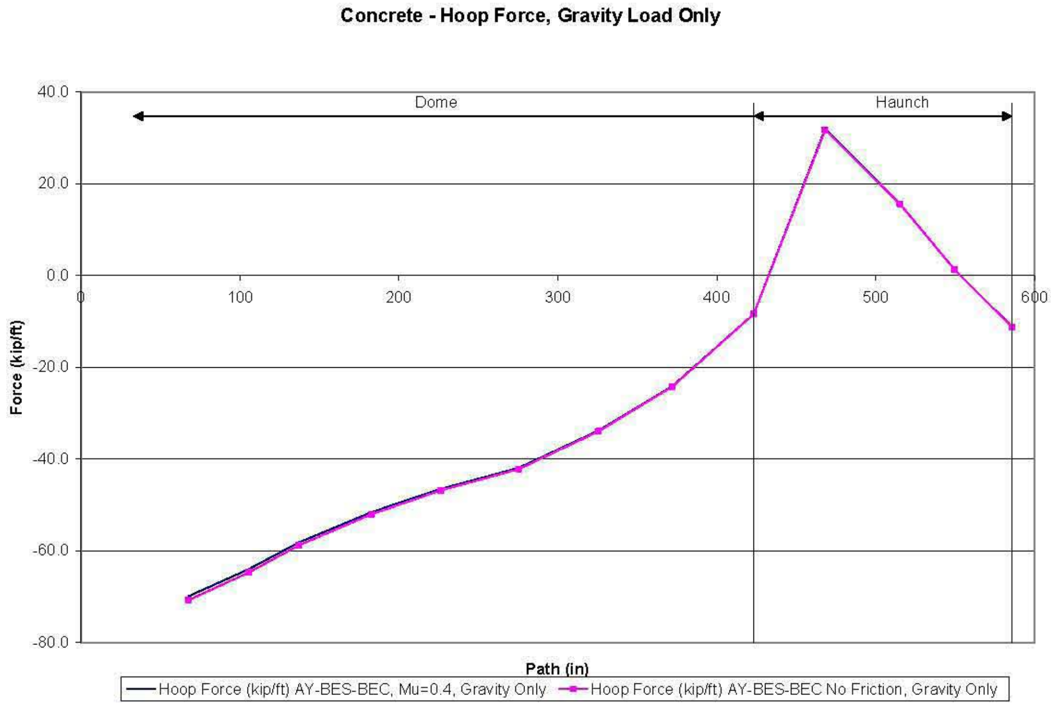


Figure 5-3. Concrete Tank Hoop Forces – Gravity Plus Seismic

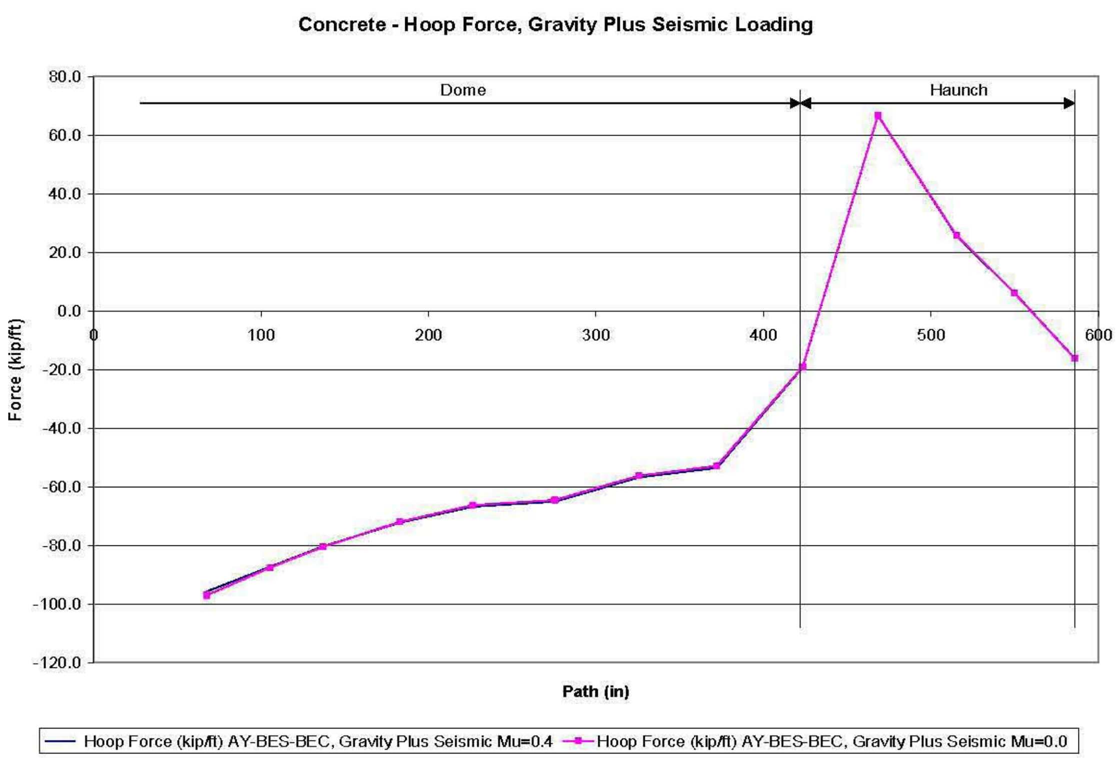


Figure 5-4. Concrete Tank Hoop Forces – Seismic Only

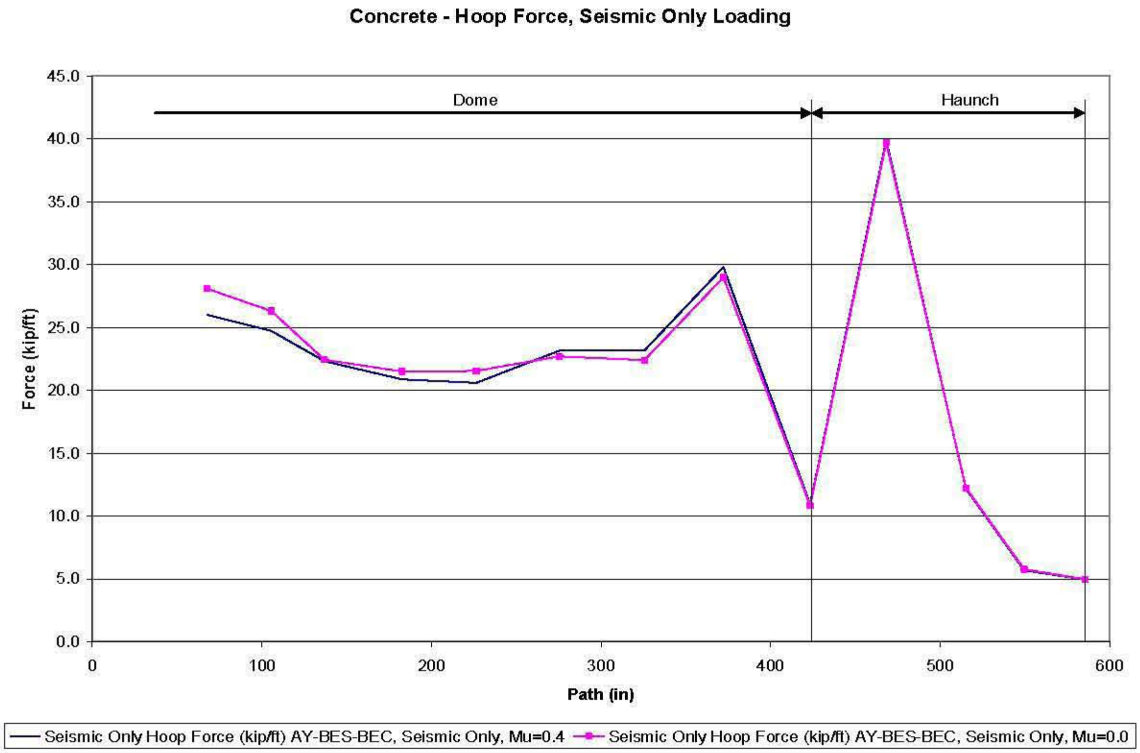


Figure 5-5. Concrete Tank Meridional Forces – Gravity Only

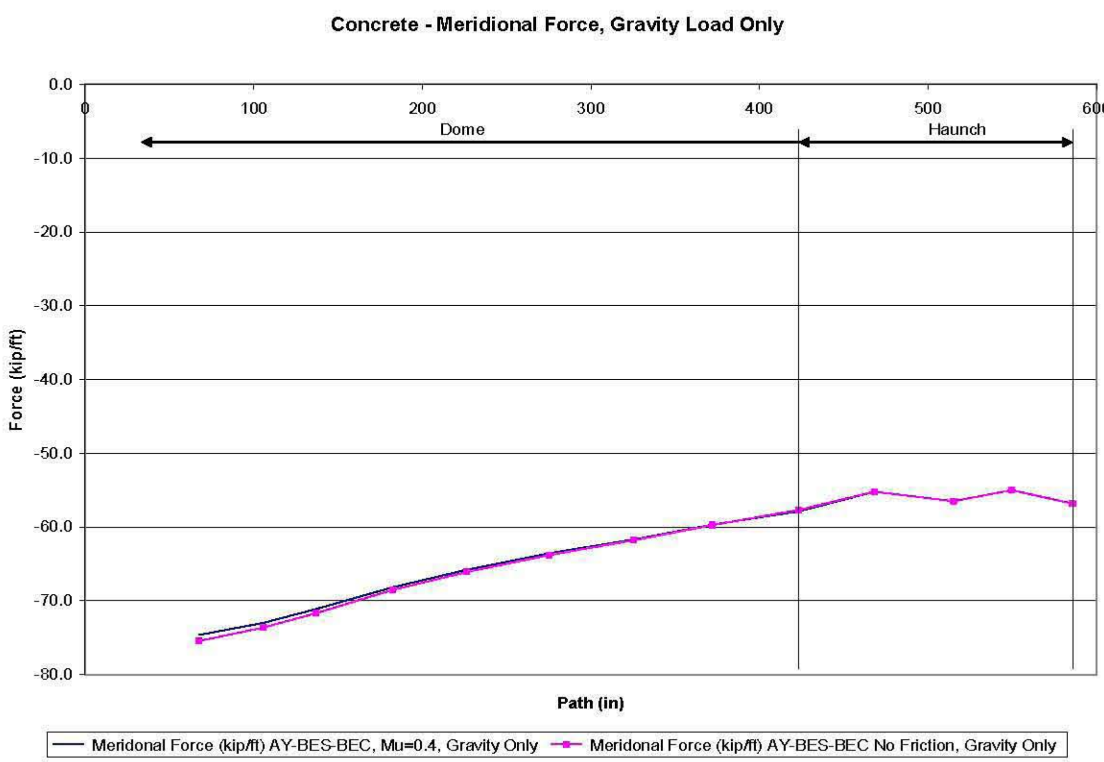


Figure 5-6. Concrete Tank Meridional Forces – Gravity Plus Seismic

Figure 5-7. Concrete Tank Meridional Forces – Seismic Only

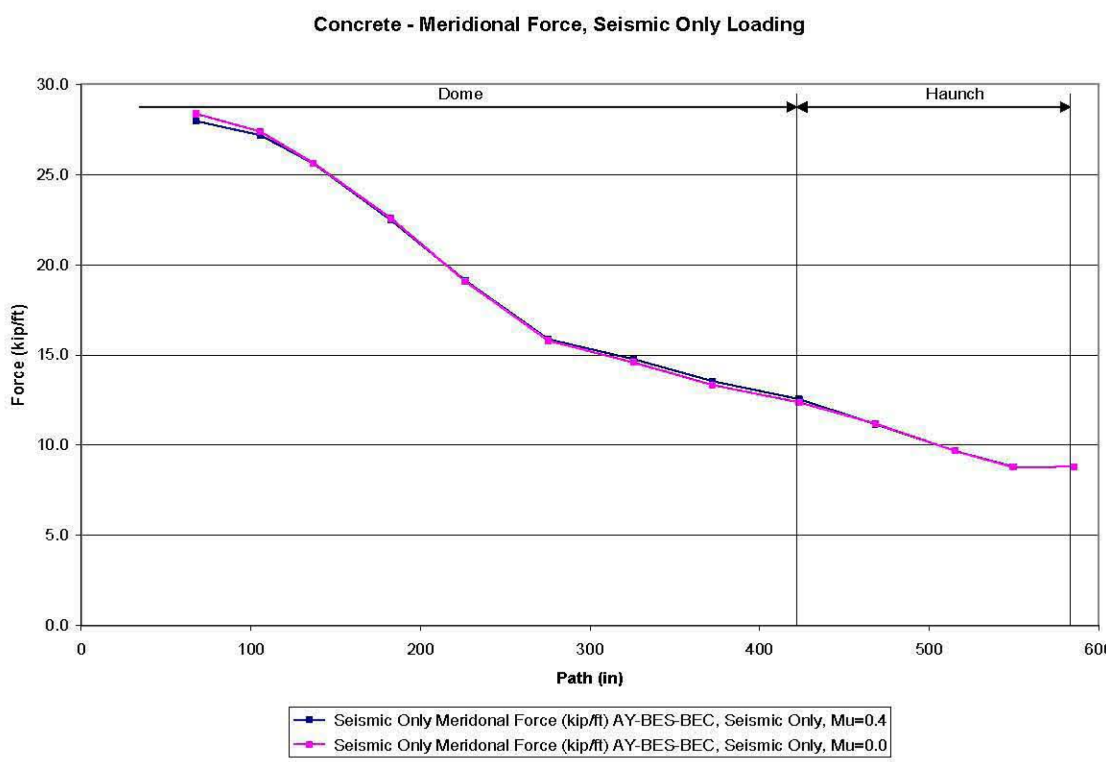


Figure 5-8. Concrete Tank Hoop Moments – Gravity Only

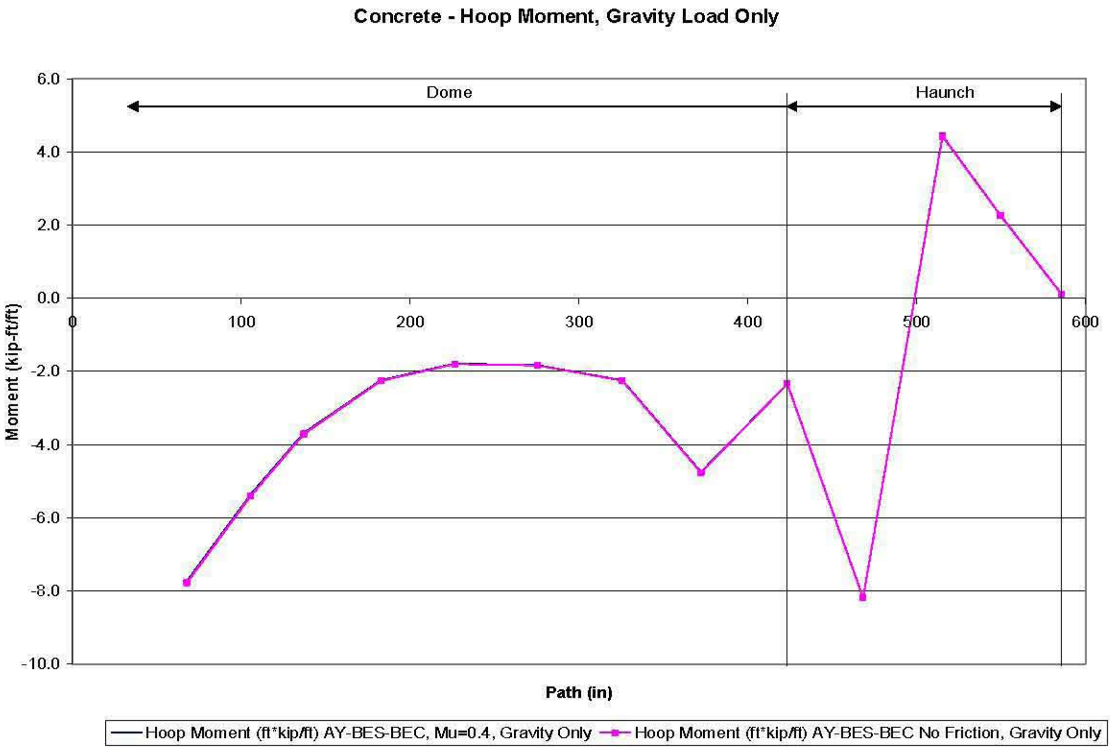


Figure 5-9. Concrete Tank Hoop Moments – Gravity Plus Seismic

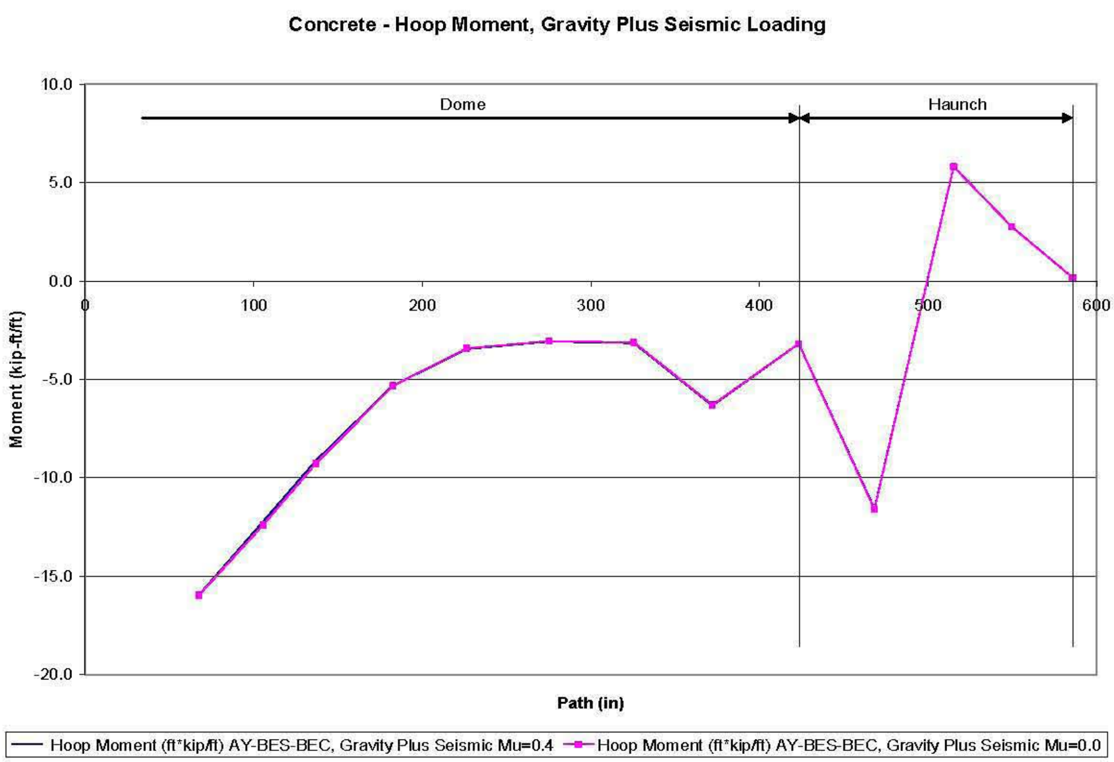


Figure 5-10. Concrete Tank Hoop Moments – Seismic Only

Figure 5-11. Concrete Tank Meridional Moments – Gravity Only

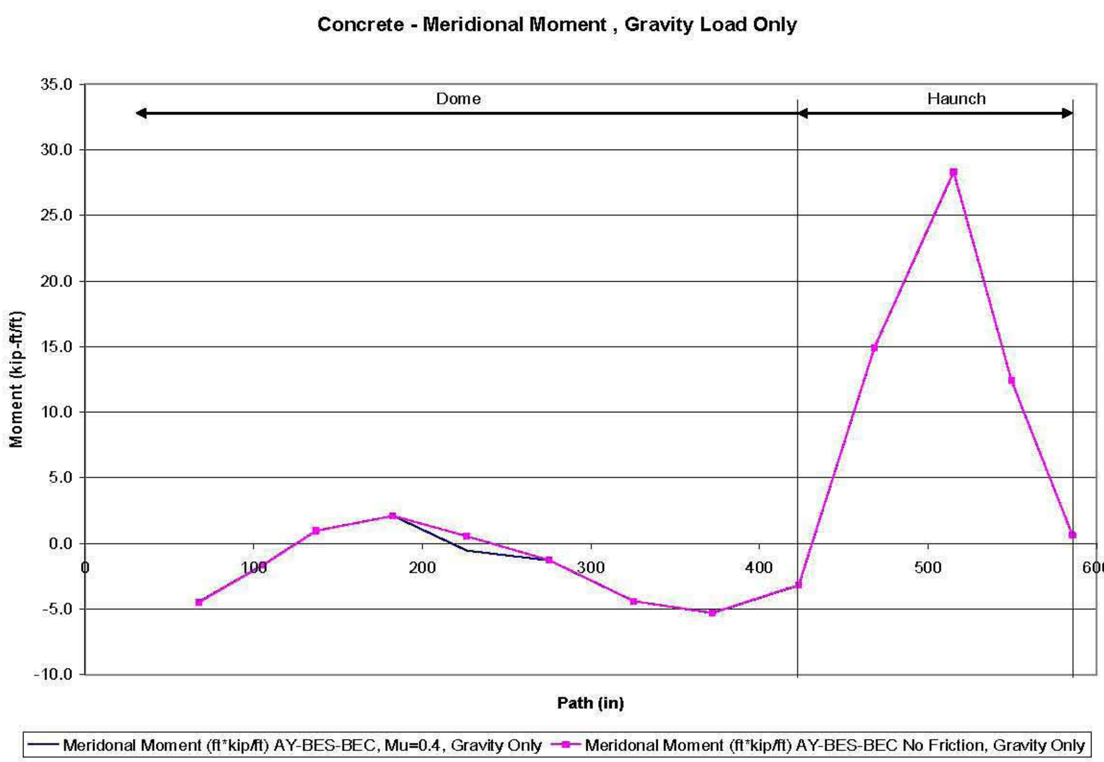


Figure 5-12. Concrete Tank Meridional Moments – Gravity Plus Seismic

Figure 5-13. Concrete Tank Meridional Moment– Seismic Only

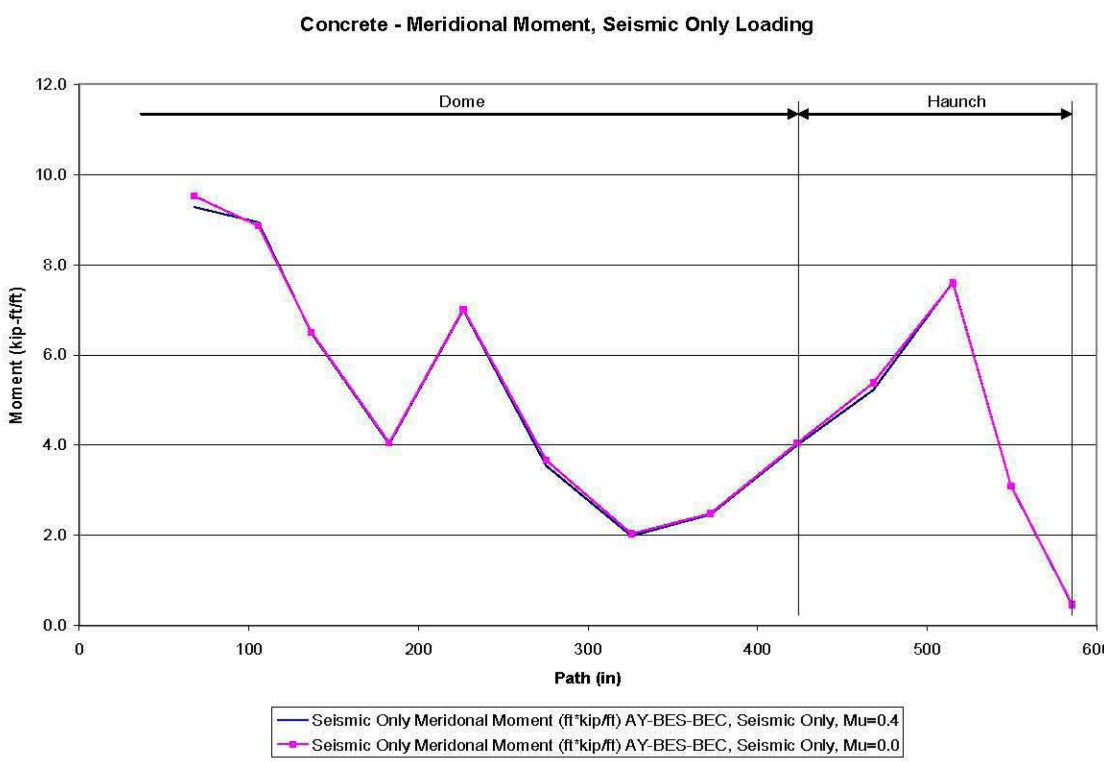


Figure 5-14. Concrete Tank In-Plane Shear Forces – Gravity Only

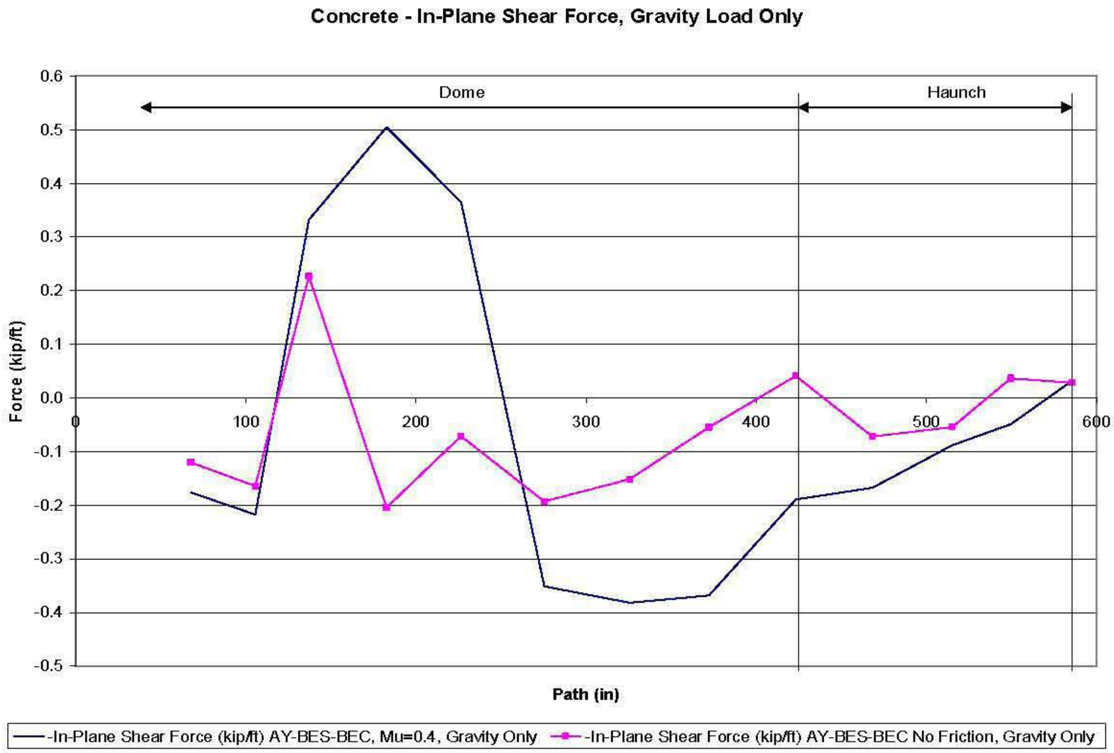


Figure 5-15. Concrete Tank In-Plane Shear Forces – Gravity Plus Seismic

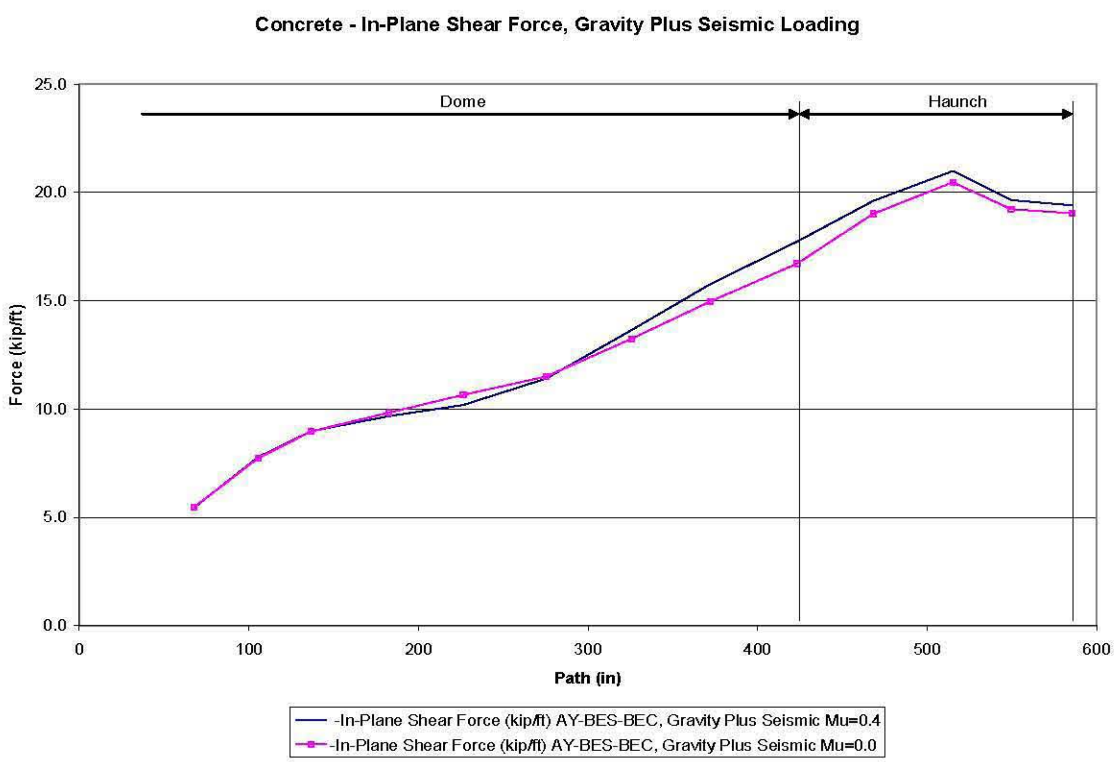


Figure 5-16. Concrete Tank In-Plane Shear Forces – Seismic Only

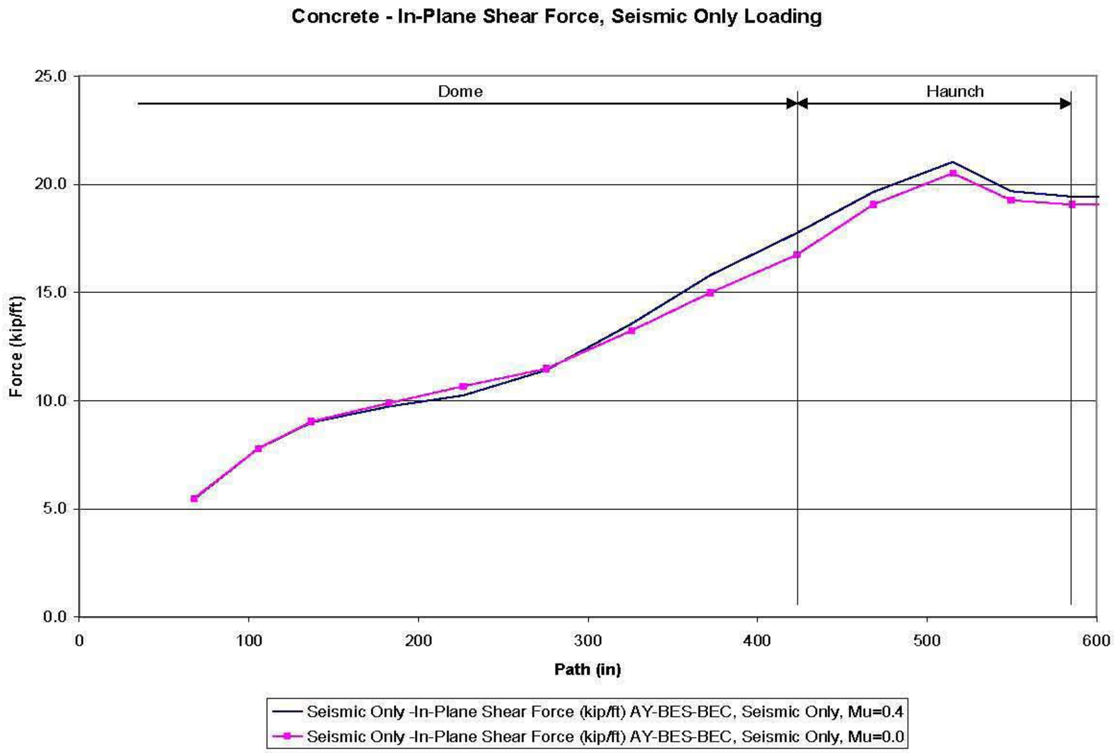


Figure 5-17. Concrete Tank Through-Wall Shear Forces – Gravity Only

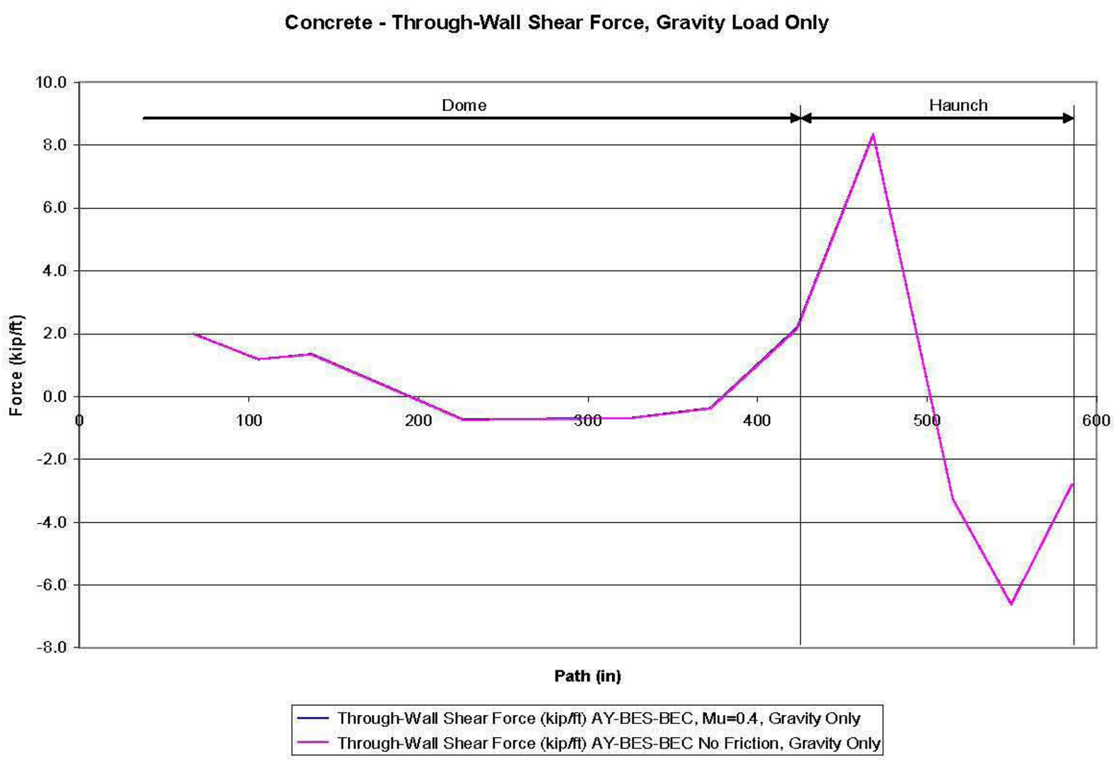


Figure 5-18. Concrete Tank Through-Wall Shear Forces – Gravity Plus Seismic

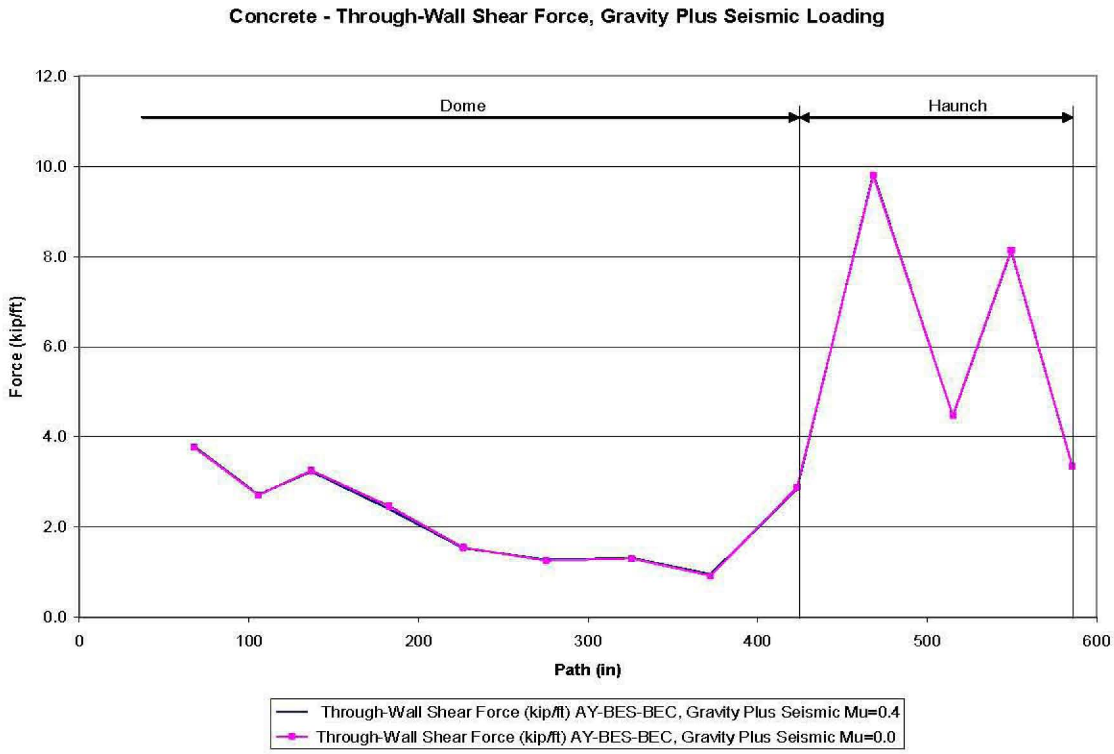
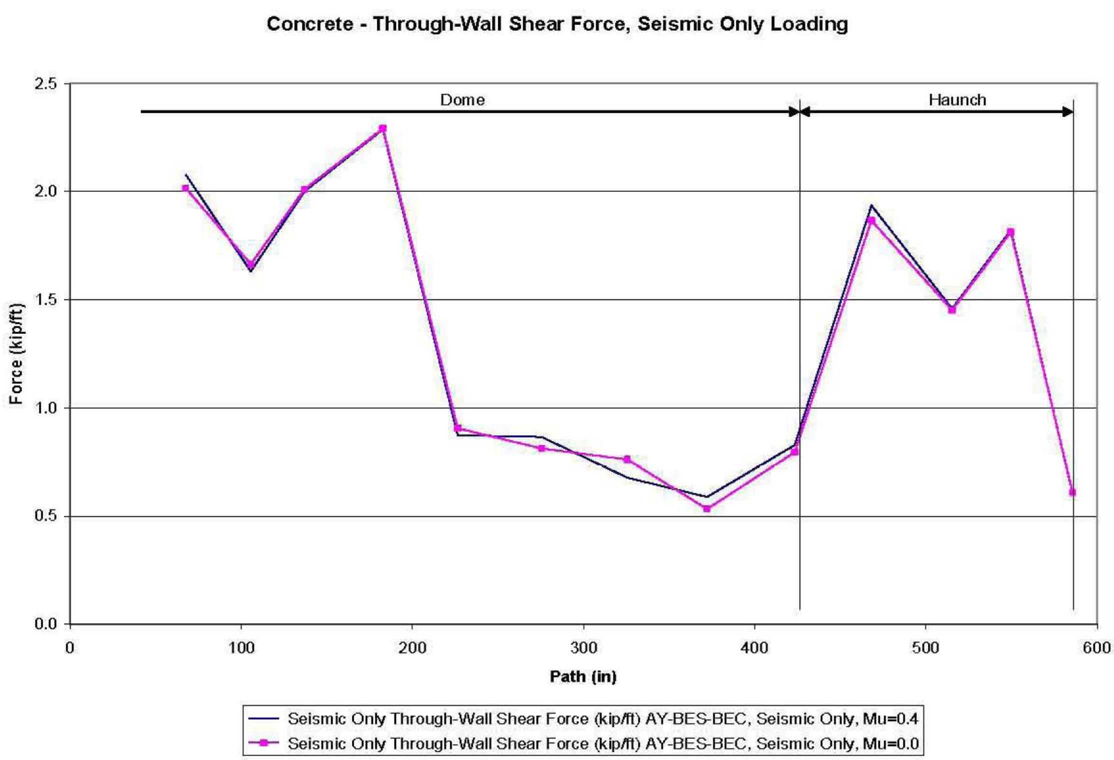


Figure 5-19. Concrete Tank Through-Wall Shear Forces – Seismic Only



5.2 PRIMARY TANK

Primary tank stresses are extracted from the model in 9 degree slices, starting near the top of the dome and moving down the wall and across the footing from the outside to the center of the tank. Only the region from the dome apex to a short distance past the tank tangent point is included for this study. Stresses were extracted for the top, middle, and bottom of each shell element. Figure 5-20 shows the first slice, with element numbers. Each of the subsequent figures shows one component of stress, comparing the results from each load case. The results presented for the primary tank stresses are enveloped minima/maxima around the circumference of the tank.

The following stresses are extracted for the primary tank SHELL143 elements at the top, middle, and bottom for each element.

- SX Hoop Stress (Meridional in floor)
- SY Meridional Stress (Hoop in floor)
- SINT Stress Intensity
- SXY In-Plane Shear Stress
- SYZ Shear Stress
- SXZ Shear Stress

Figures are grouped in sets showing the stress for gravity loading first, total demand from the transient analysis (gravity plus seismic), and then only the seismic portion. The seismic load is simply the difference between the full transient loading and gravity loading only. For the primary tank, hoop stresses at the shell middle, Meridional stresses at the shell top and bottom, and in-plane shear stresses at the shell middle are presented in the following figures.

- Figure 5-21. Primary Hoop Stress (Middle) – Gravity Only
- Figure 5-22. Primary Tank Hoop Stress (Middle) – Gravity Plus Seismic
- Figure 5-23. Primary Tank Hoop Stress (Middle) – Seismic Only
- Figure 5-24. Primary Meridional Stress (Inside) – Gravity Only
- Figure 5-25. Primary Tank Meridional Stress (Inside) – Gravity Plus Seismic
- Figure 5-26. Primary Tank Meridional Stress (Inside) – Seismic Only
- Figure 5-27. Primary Meridional Stress (Outside) – Gravity Only
- Figure 5-28. Primary Tank Meridional Stress (Outside) – Gravity Plus Seismic
- Figure 5-29. Primary Tank Meridional Stress (Outside) – Seismic Only
- Figure 5-30. Primary Tank In-Plane Shear Stress (Middle) – Gravity Only
- Figure 5-31. Primary Tank In-Plane Shear Stress (Middle) – Gravity Plus Seismic
- Figure 5-32. Primary Tank In-Plane Shear Stress (Middle) – Seismic Only

Figure 5-20. Primary Tank Element Retreival Sequence Starting Numbers

Figure 5-21. Primary Hoop Stress (Middle) – Gravity Only

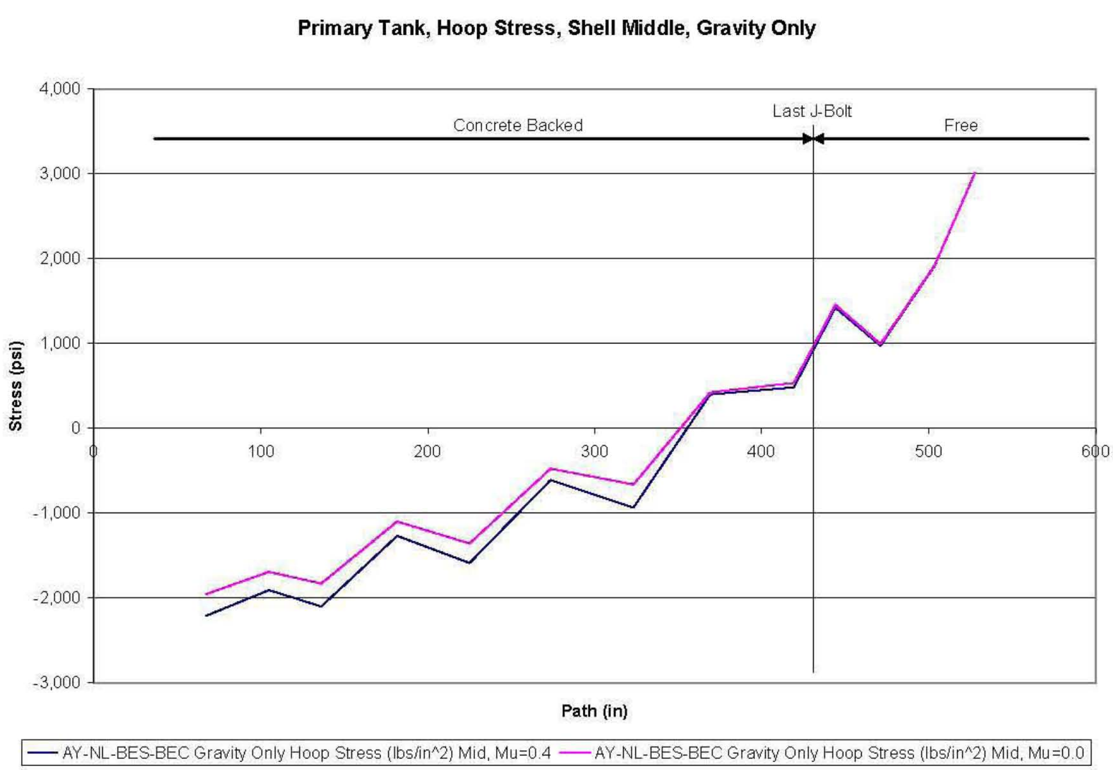


Figure 5-22. Primary Tank Hoop Stress (Middle) – Gravity Plus Seismic

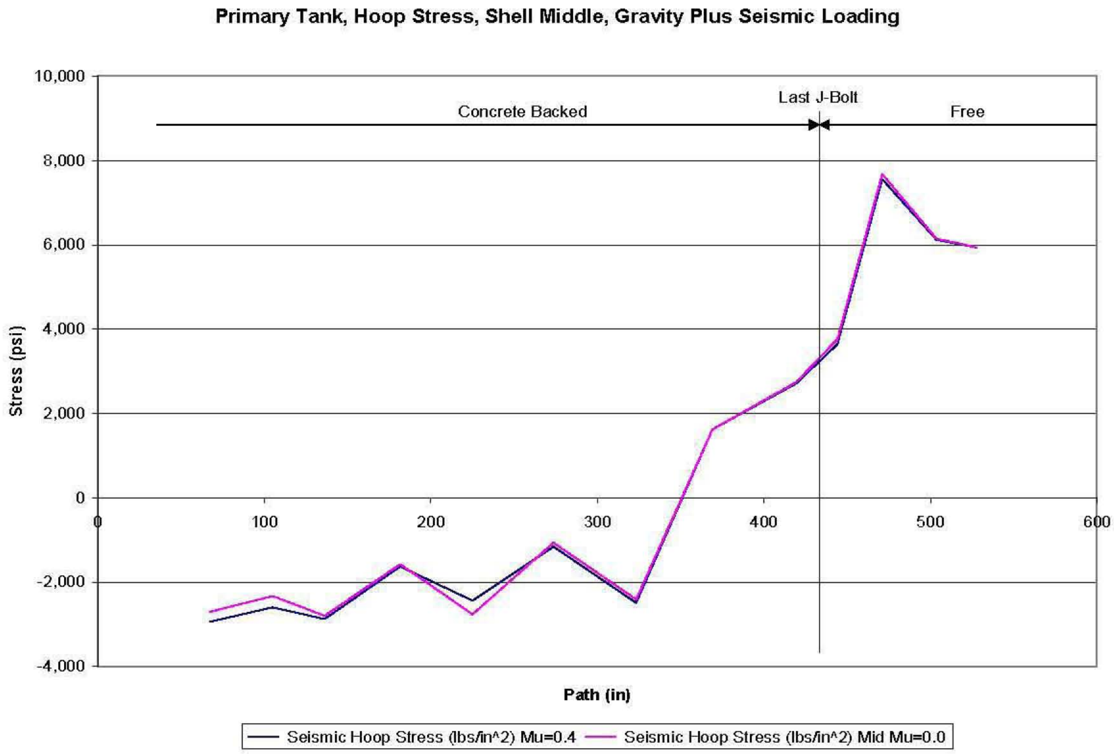


Figure 5-23. Primary Tank Hoop Stress (Middle) – Seismic Only

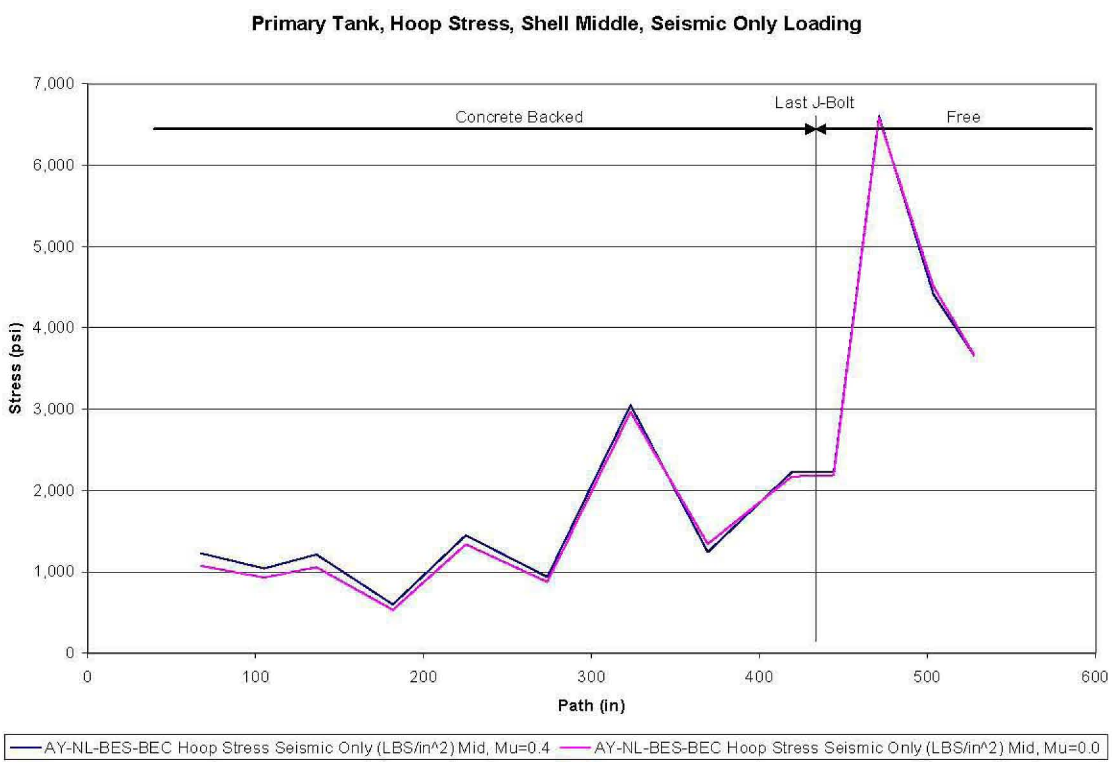


Figure 5-24. Primary Meridional Stress (Inside) – Gravity Only

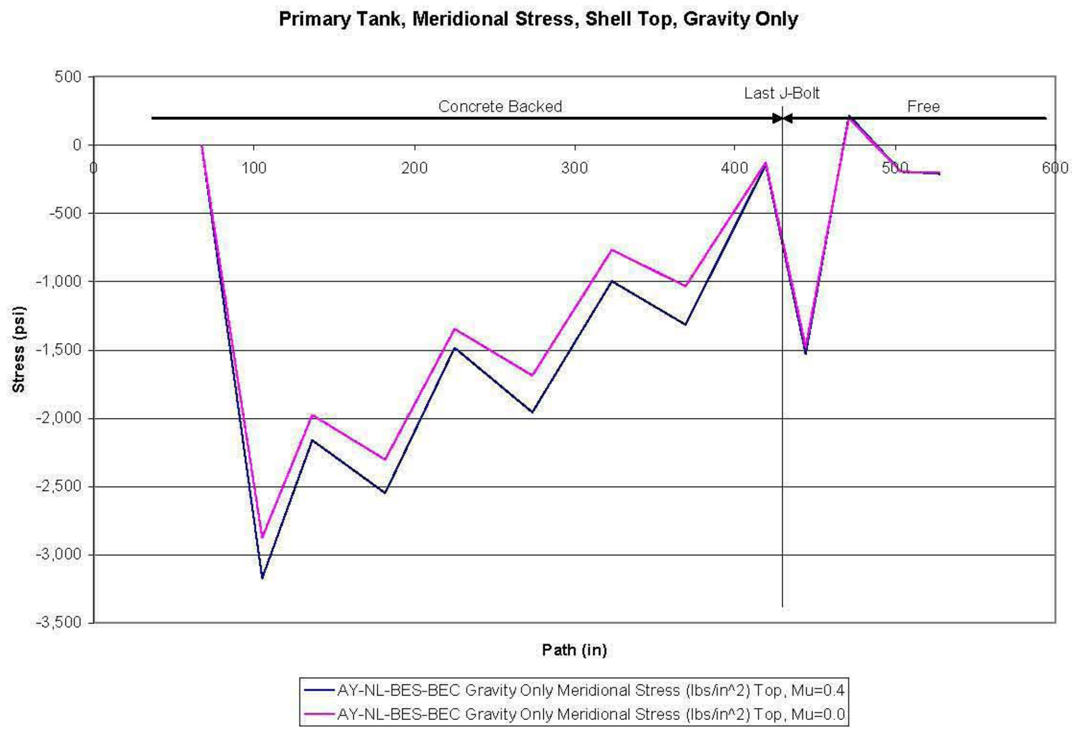


Figure 5-25. Primary Tank Meridional Stress (Inside) – Gravity Plus Seismic

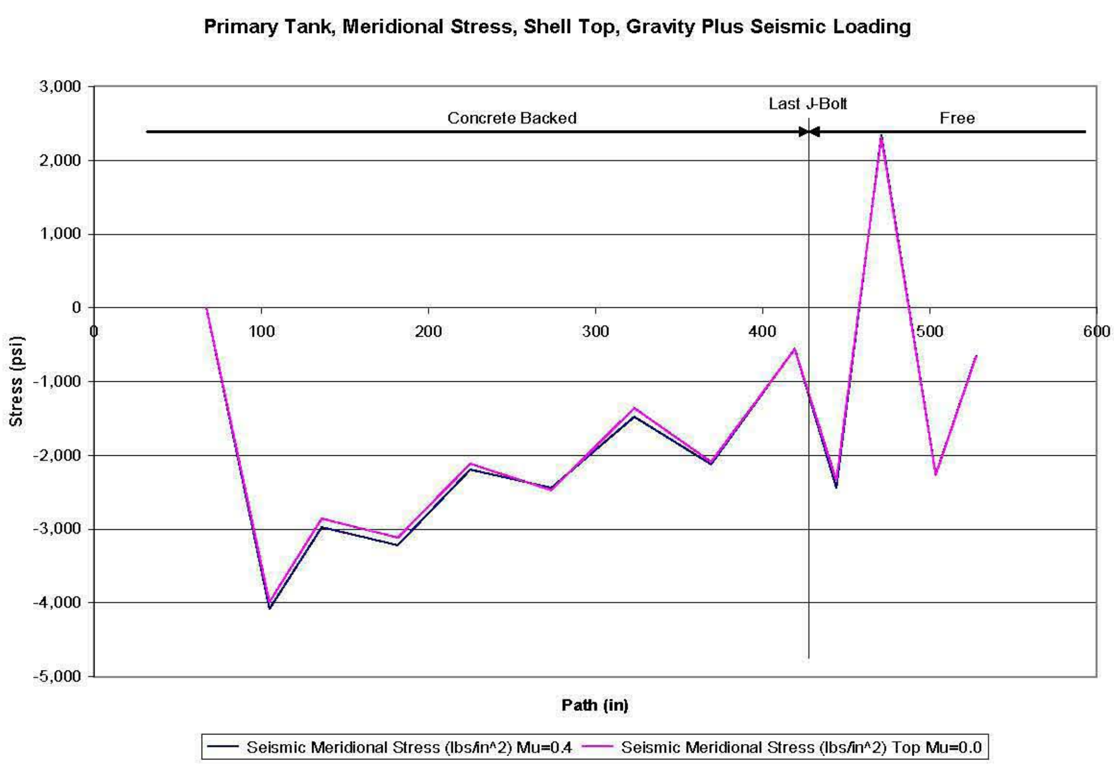


Figure 5-26. Primary Tank Meridional Stress (Inside) – Seismic Only

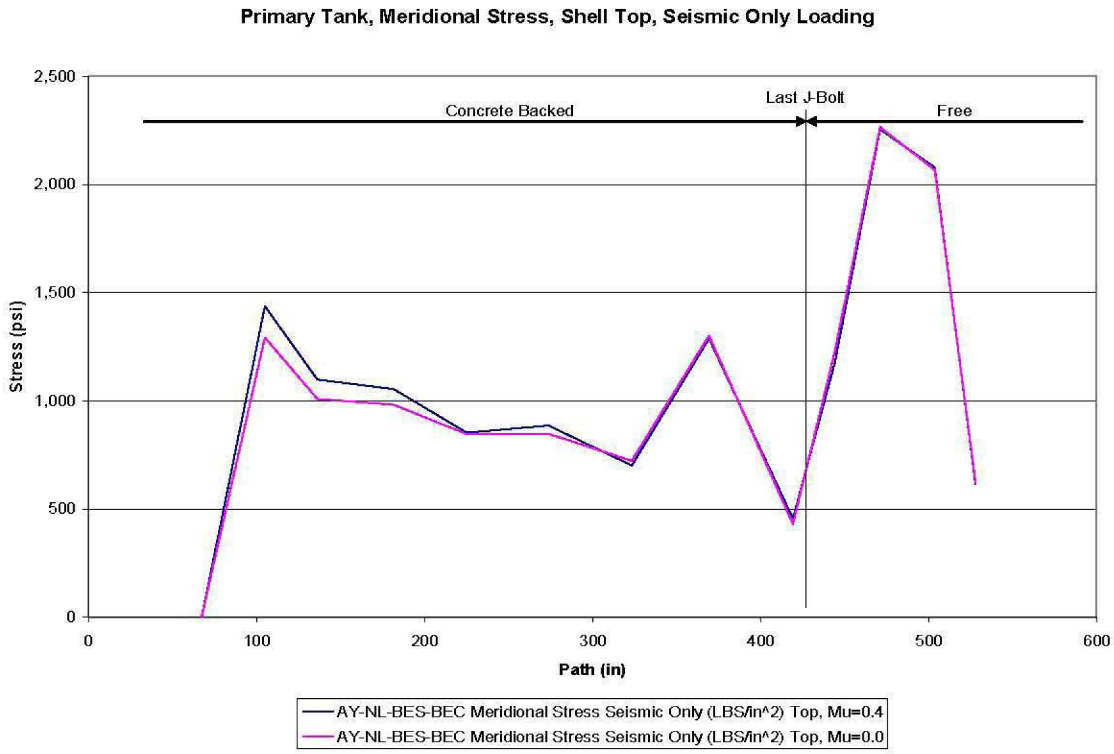


Figure 5-27. Primary Meridional Stress (Outside) – Gravity Only

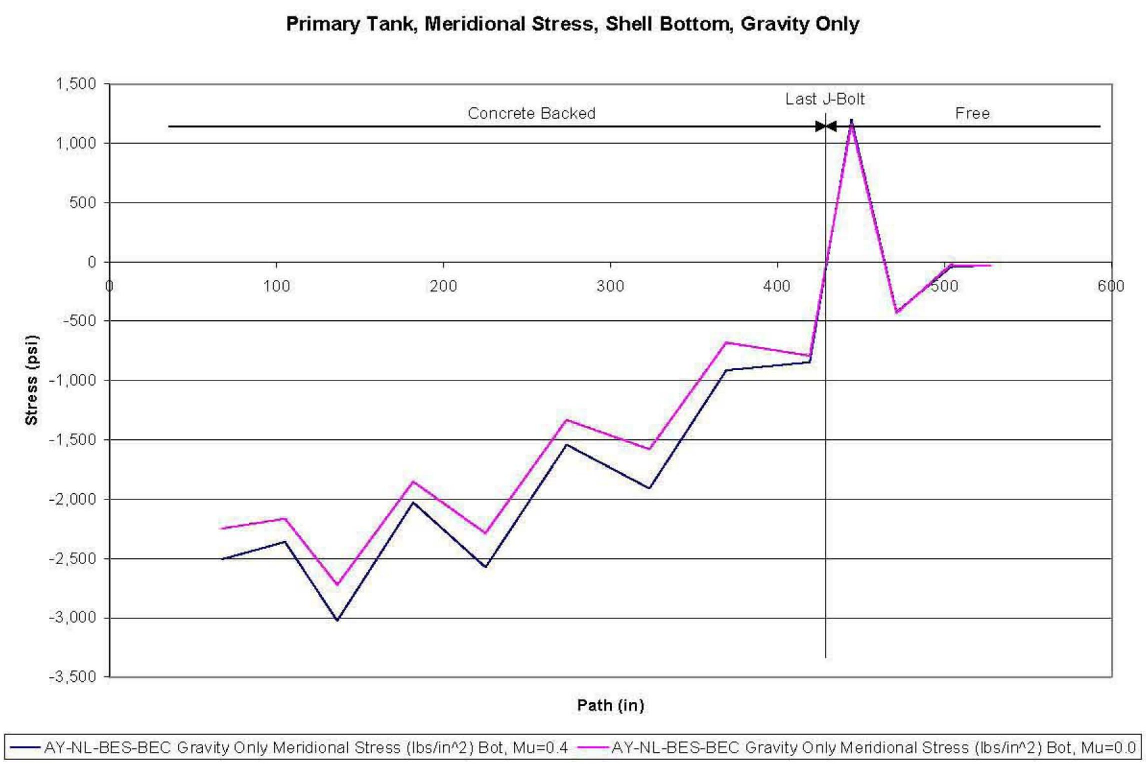


Figure 5-28. Primary Tank Meridional Stress (Outside) – Gravity Plus Seismic

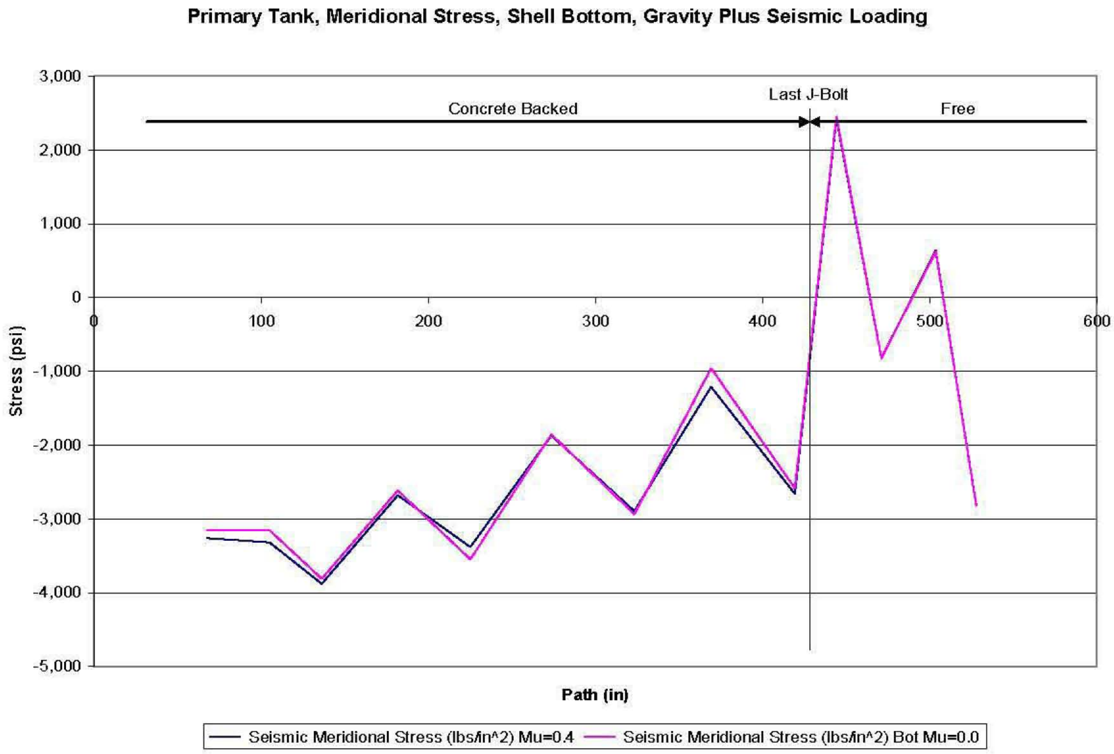


Figure 5-29. Primary Tank Meridional Stress (Outside) – Seismic Only

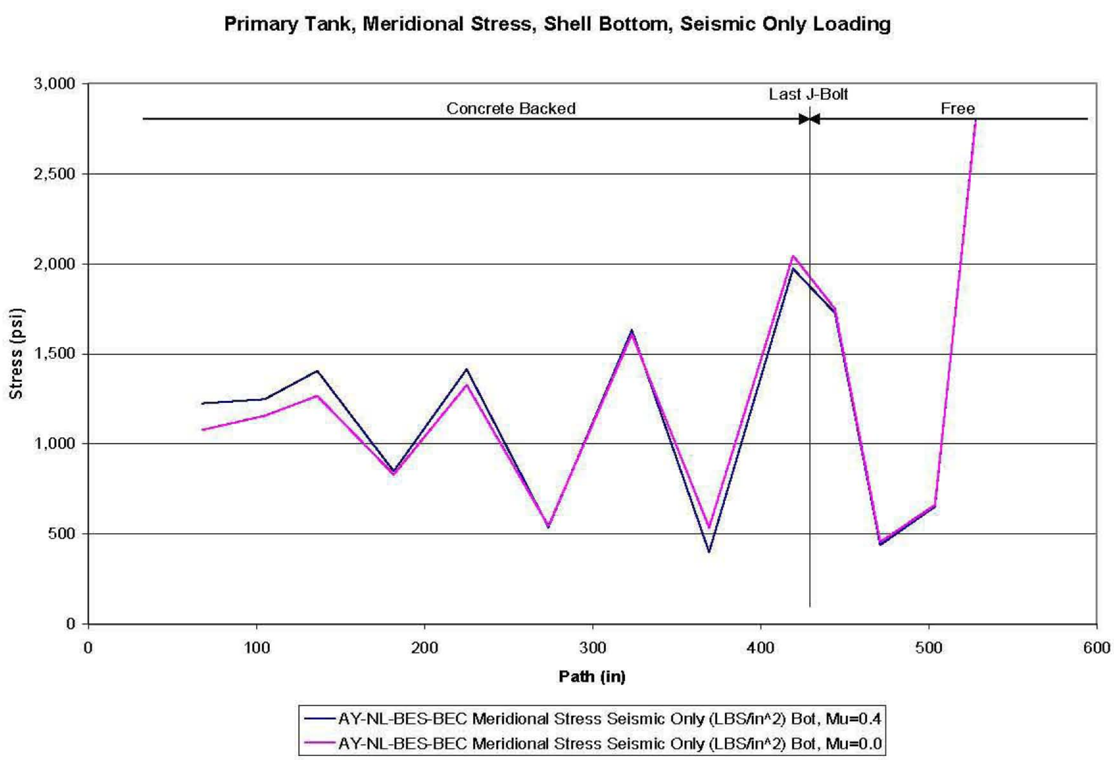


Figure 5-30. Primary Tank In-Plane Shear Stress (Middle) – Gravity Only

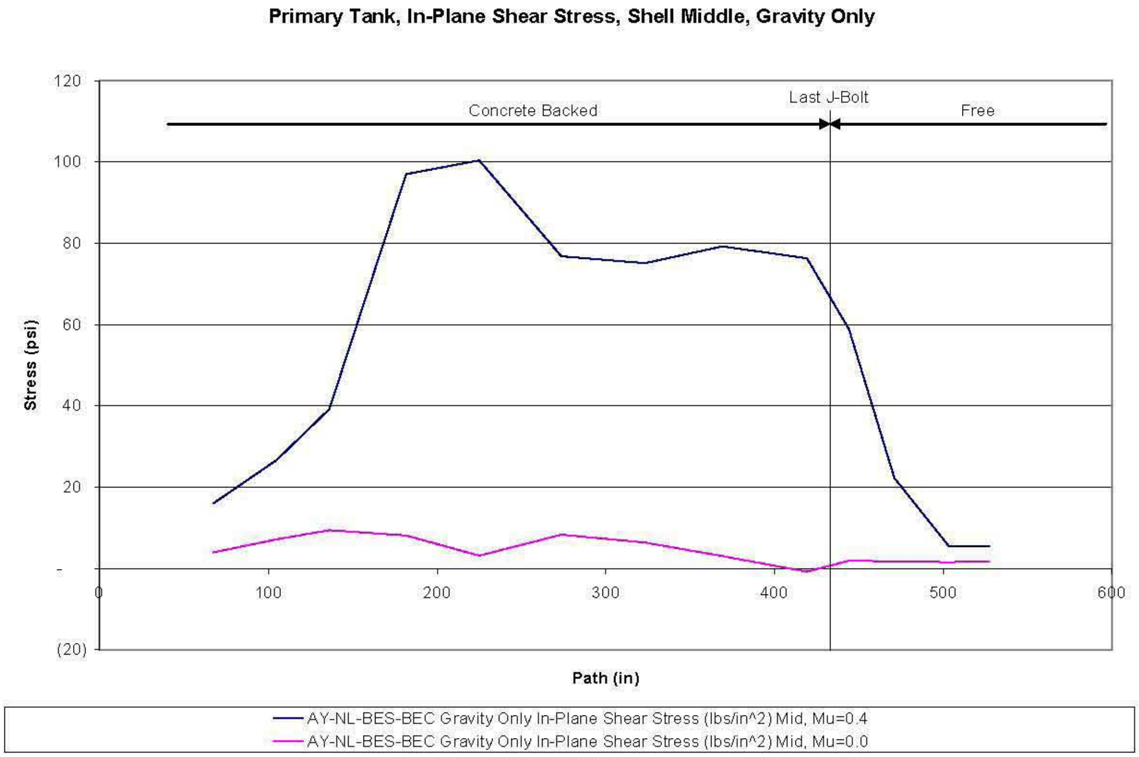


Figure 5-31. Primary Tank In-Plane Shear Stress (Middle) – Gravity Plus Seismic

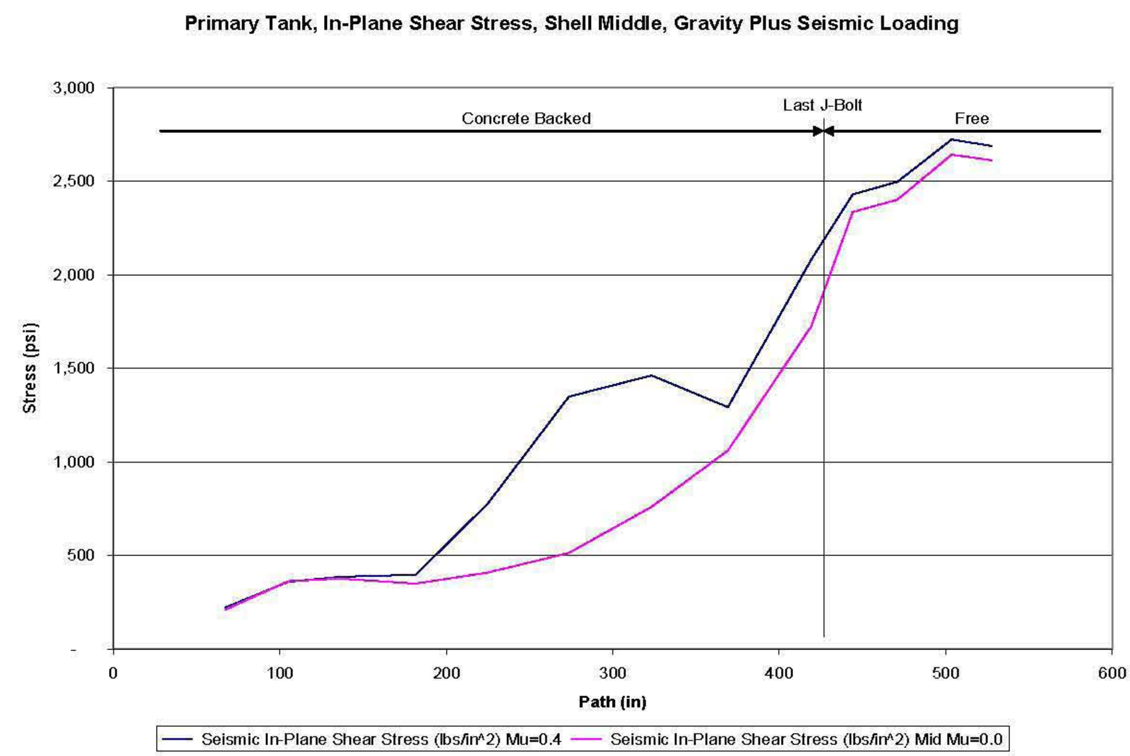
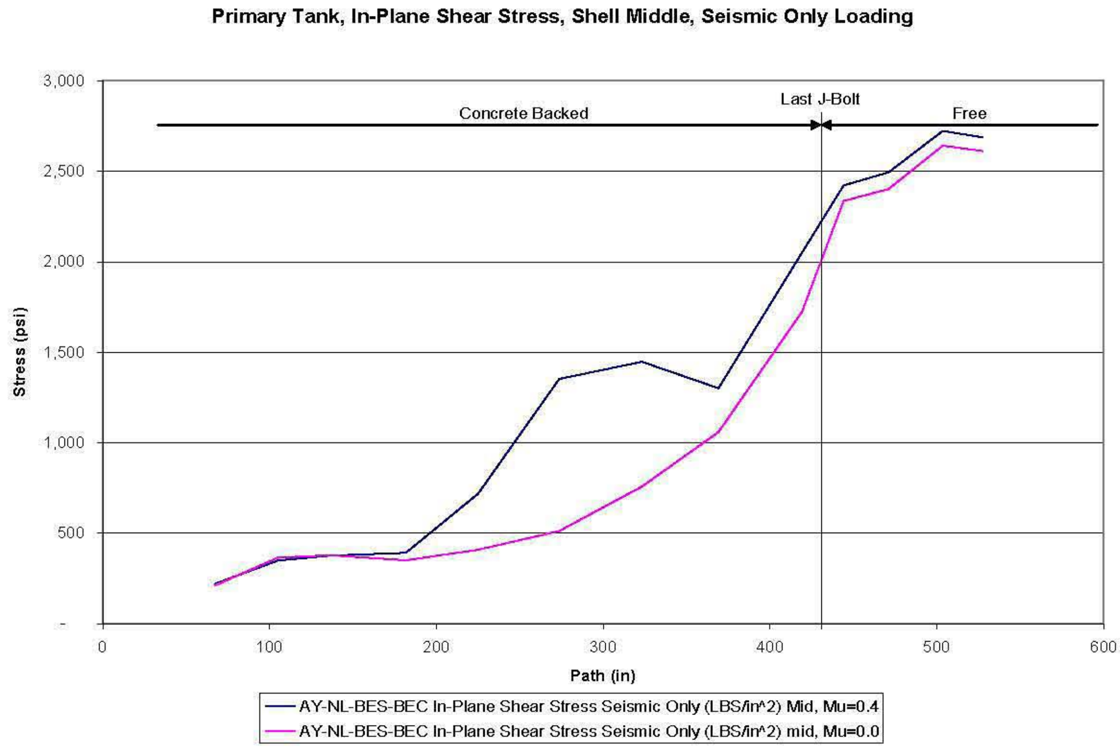


Figure 5-32. Primary Tank In-Plane Shear Stress (Middle) – Seismic Only



5.3 J-BOLTS

Axial and shear forces were extracted for the J-bolt elements. Figure 5-33 shows the element numbers for the first five set of J-bolts. Because J-bolt elements are placed at the edges of each slice, a total of twenty-one sets are extracted, but are extracted by radius instead of angle as was done for the concrete and primary tank. The following forces were extracted from the BEAM44 element results.

- SMISC7 Axial force (Element X)
- SMISC8 Shear force (Element Y)
- SMISC9 Shear force (Element Z)

After enveloping the forces around the circumference of the tank, the forces are re-allocated on a per-bolt basis using the information from Rinker, et al. (2006a). The total shear force is calculated by combining the two orthogonal shears extracted from the model by the SRSS method. The results are presented in the following figures:

- Figure 5-34. J-bolts –Axial Force - Gravity Only
- Figure 5-35. J-bolts –Axial Force - Gravity Plus Seismic
- Figure 5-36. J-bolts –Axial Force - Seismic Only
- Figure 5-37. J-bolts – Shear Force - Gravity Only
- Figure 5-38. J-bolts – Shear Force - Gravity Plus Seismic

- Figure 5-39. J-bolts – Shear Force - Seismic Only

Figure 5-33. J-bolt Element Retreival Sequence Starting Numbers

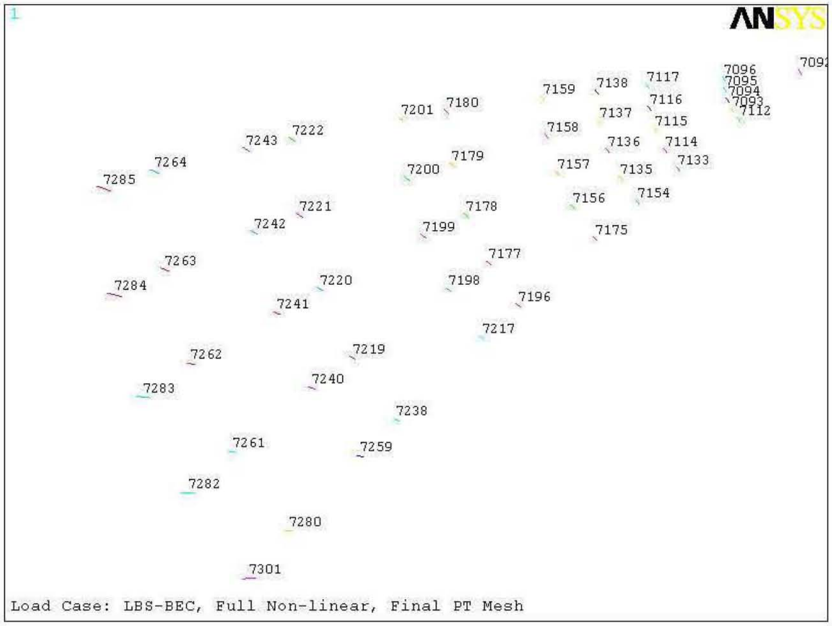


Figure 5-34. J-bolts –Axial Force - Gravity Only

Figure 5-35. J-bolts –Axial Force - Gravity Plus Seismic

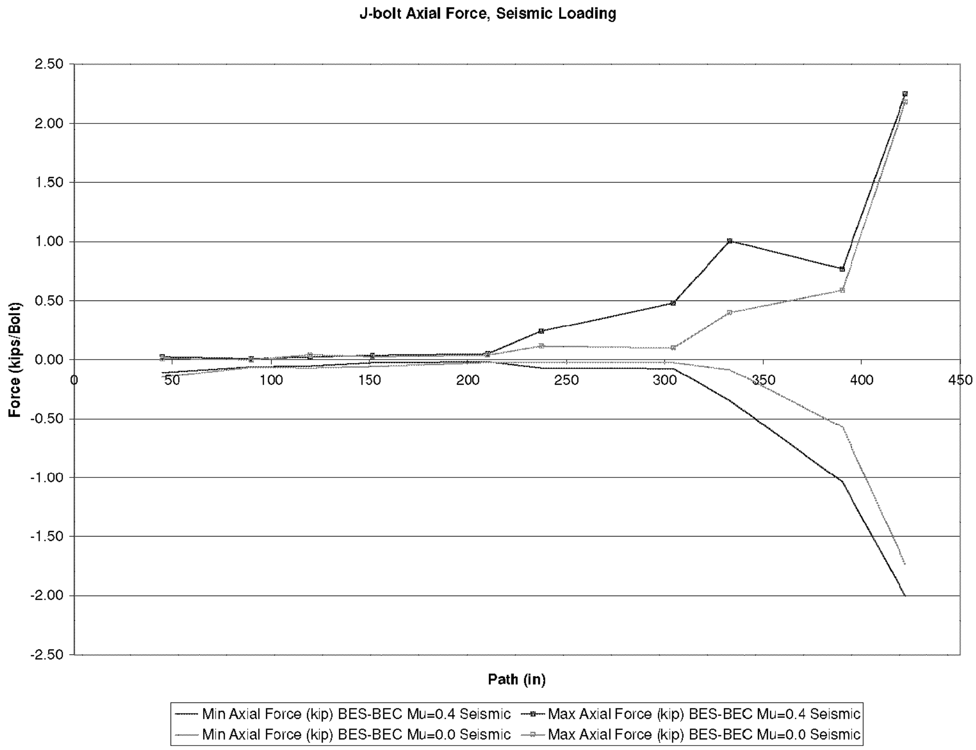


Figure 5-36. J-bolts –Axial Force - Seismic Only

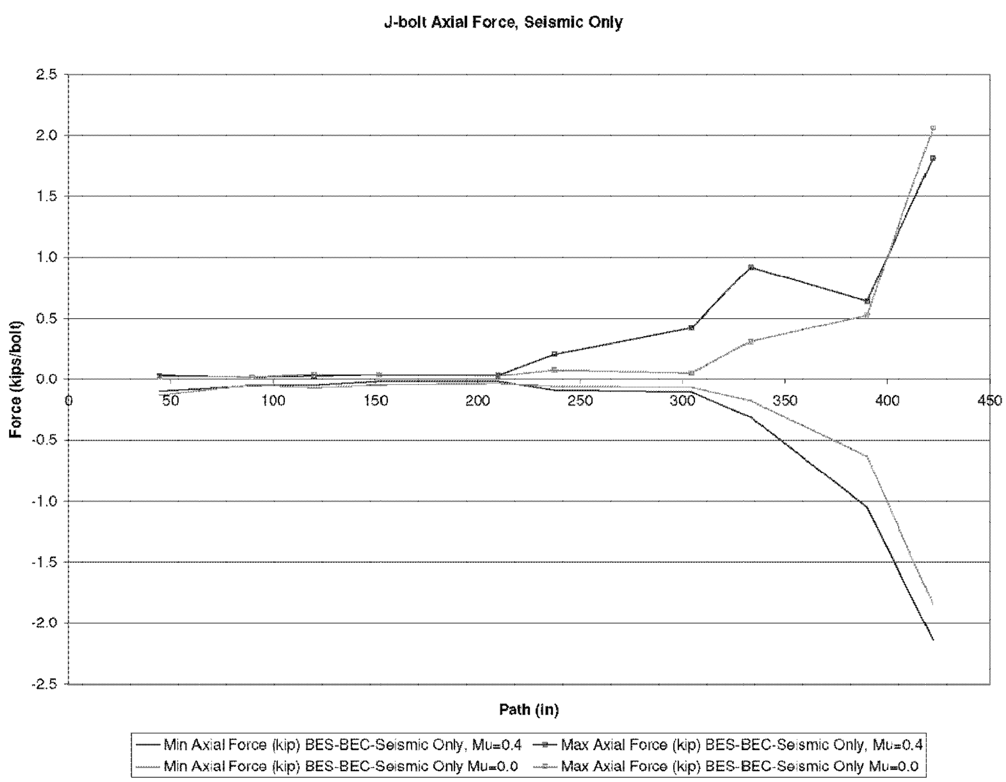


Figure 5-37. J-bolts – Shear Force - Gravity Only

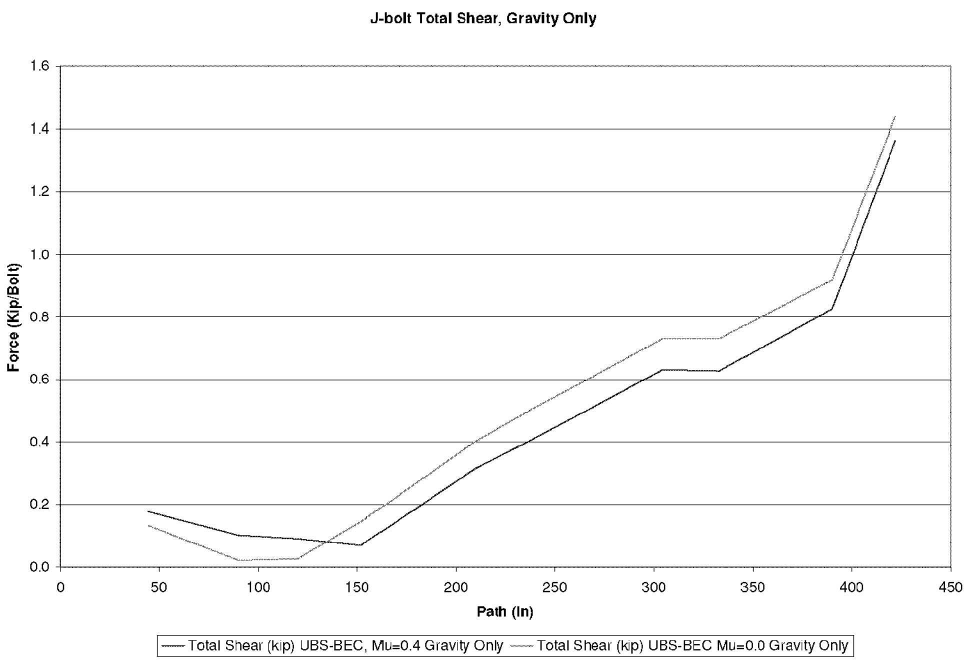


Figure 5-38. J-bolts – Shear Force - Gravity Plus Seismic

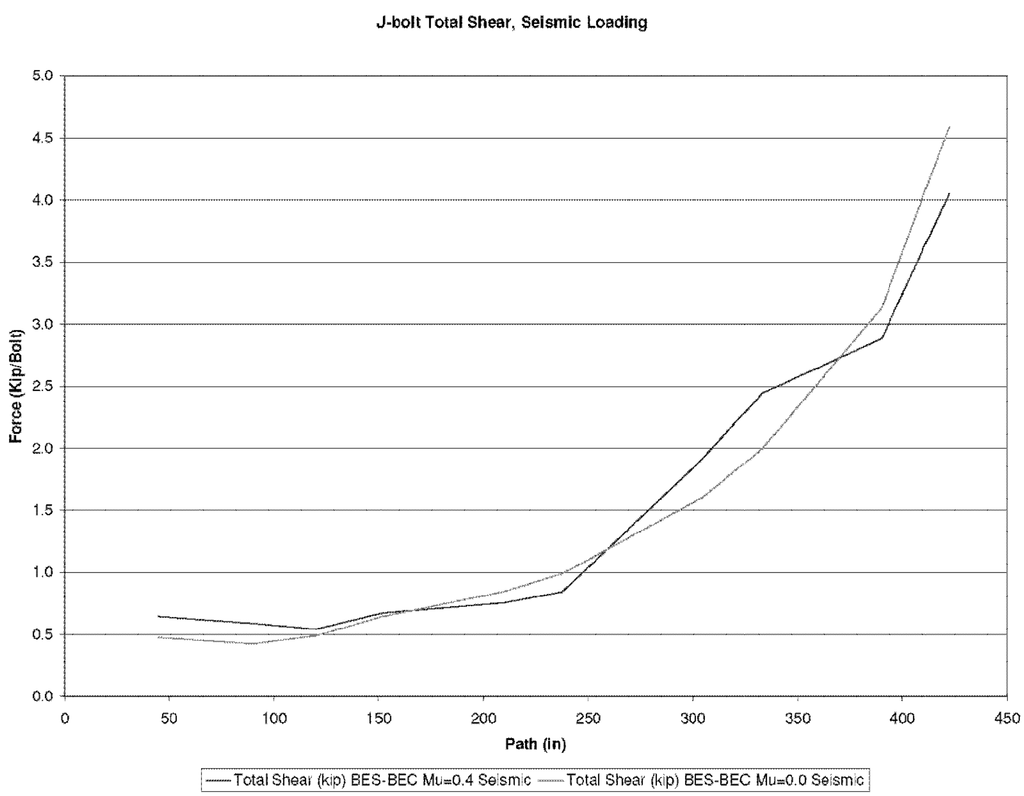
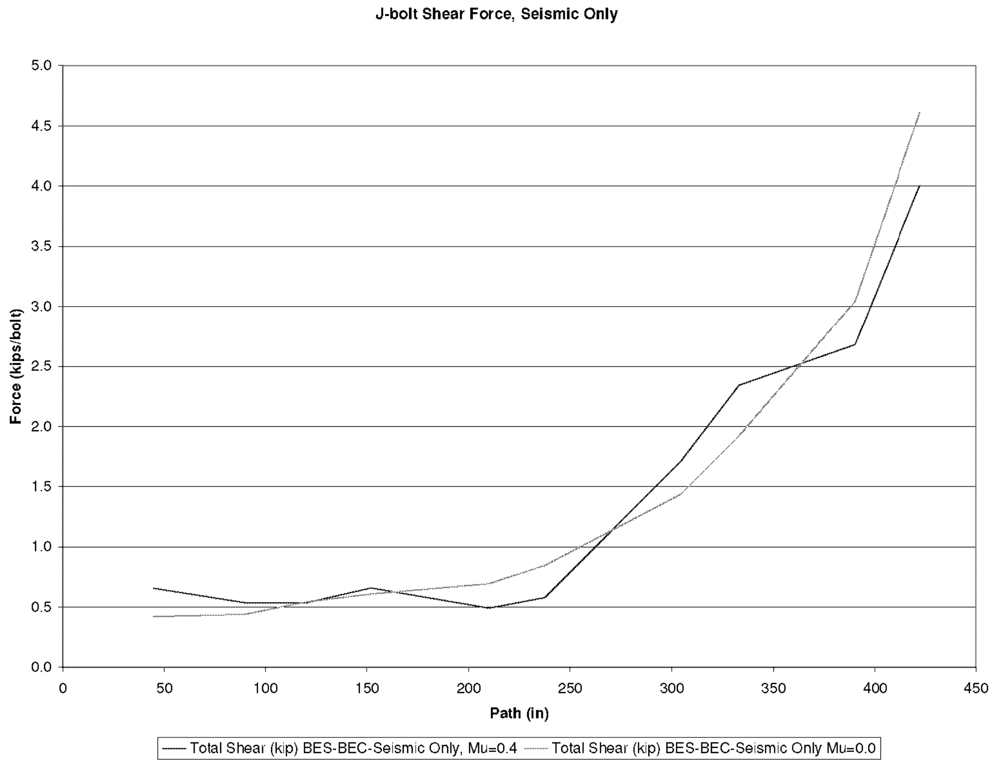


Figure 5-39. J-bolts – Shear Force - Seismic Only



6.0 CONTACT ELEMENT RESULTS

6.1 DOME CONTACTS

Dome contact data are extracted from the model in 9 degree slices, starting near the top of the dome and moving out to the tangent point of the primary tank. Contact normal and other contact data were extracted for the interface between primary tank and concrete dome. Figure 6-1 shows the location and element numbers for first slice of contact elements. The following data was extracted for each CONTA173 element

- CONT-PRES Normal Contact Pressure
- CONT-SLIDE Contact Lateral Displacement
- CONT-GAP Contact Gap Distance
- CONT-STAT Contact Status (Open, Closed, Sliding)

For each load case, the minimum and maximum contact pressure, lateral displacements, and gaps are compared. The figures for each component are grouped by gravity loading only, gravity plus seismic, and seismic. For the dome contact interface, the following figures are provided.

- Figure 6-2. Primary Tank/Concrete Dome Contact Element Contact Pressure – Gravity Only
- Figure 6-3. Primary Tank/Concrete Dome Contact Element Maximum Contact Pressure – Gravity Plus Seismic
- Figure 6-4. Primary Tank/Concrete Dome Contact Element Maximum Contact Pressure – Seismic Only

Figure 6-1. Primary Tank Dome Contact Element Retreival Sequence Starting Numbers

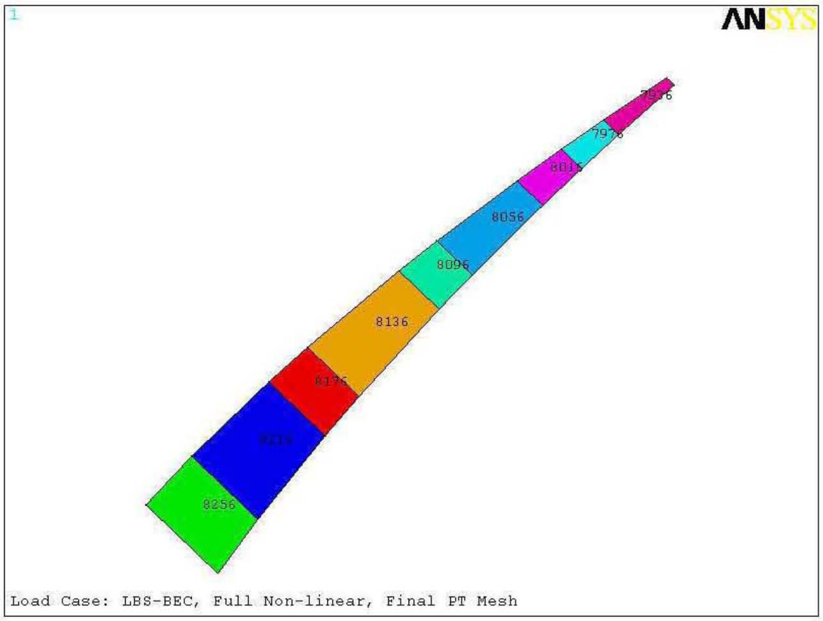


Figure 6-2. Primary Tank/Concrete Dome Contact Element Contact Pressure – Gravity Only

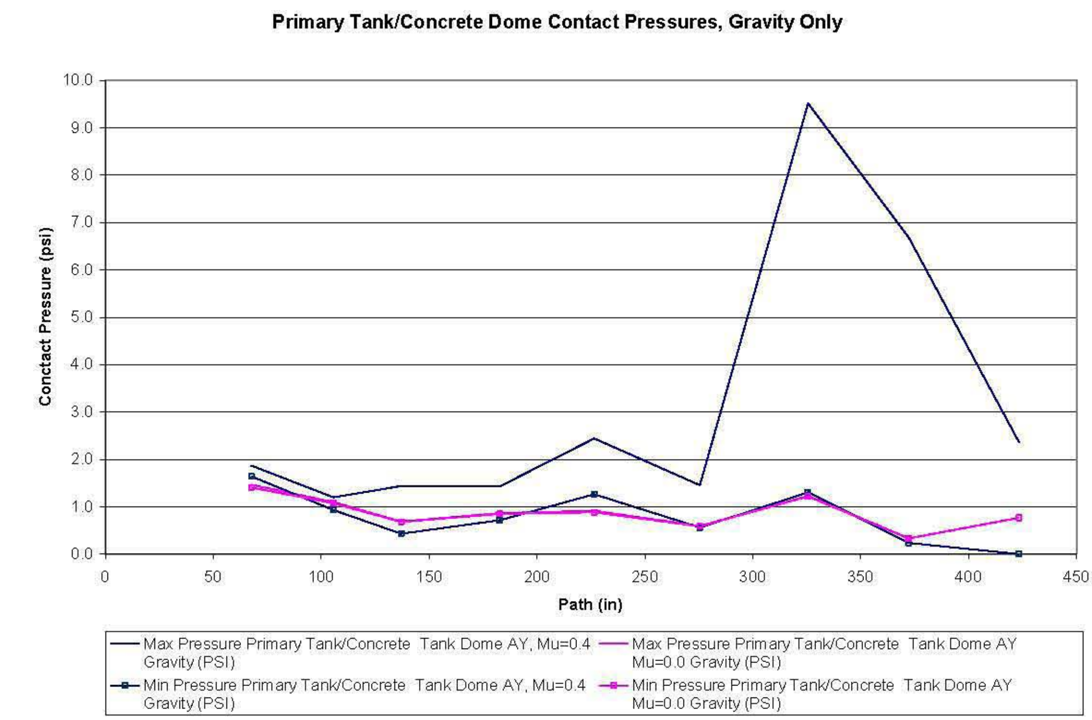


Figure 6-3. Primary Tank/Concrete Dome Contact Element Maximum Contact Pressure – Gravity Plus Seismic

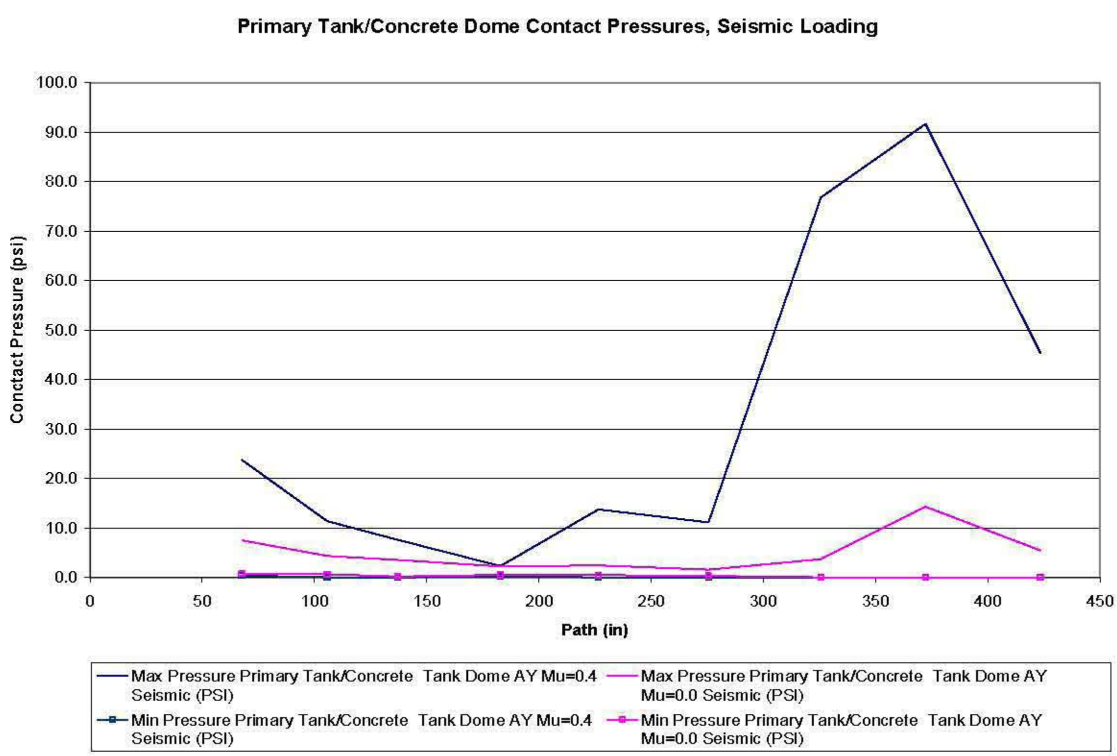
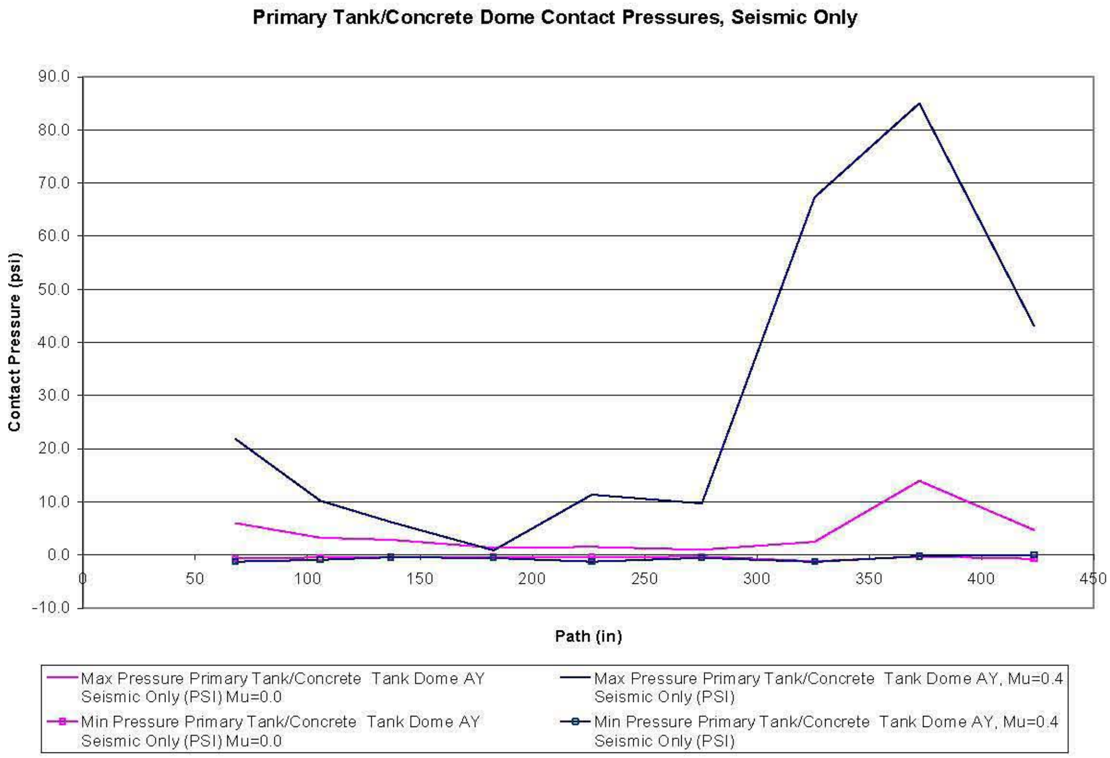


Figure 6-4. Primary Tank/Concrete Dome Contact Element Maximum Contact Pressure – Seismic Only



7.0 REFERENCES

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Rinker, M.W., et al. 2006b, *Hanford Double-Shell Tank Thermal and Seismic Project – Summary of Combined Thermal and Operating Loads*, RPP-RPT-28968, Rev. 1, Prepared by Pacific Northwest National Laboratory, Richland, Washington.

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PNNL, 2003, *Statement of Work, DST Seismic Analysis, RFP #1922*, Pacific Northwest National Laboratory, Richland, Washington.

Rinker, M.W., J.E. Deibler, K.I. Johnson, S.P. Pilli, C.E. Guzman-Leong, and O.D. Mullen, 2004, *Hanford Double-Shell Tank Thermal and Seismic Project – Thermal and Operating Loads Analysis*, RPP-RPT-23308, Rev. 0, Pacific Northwest National Laboratory, Richland, Washington.

8.0 COMPUTER RUN LIST

Computer File Listing

Program Used: ____**ANSYS®**______________________ **Version Used:** __**8.1**

V&V Reference: ___**M&D-V&V-ANS-81-001, Revision 2**_____________

Workstation used: __**F-14 Tomcat**_______________

Error Report Reviewed for Applicability: YES __X__ NO _______

Due to the large number of input and output files associated with each run, file listings are included in the appendix containing load case or study results data. The appendices are as follows:

- Appendix A Text of ANSYS® Input Files
- Appendix B Best Estimate Soil, Best Estimate Concrete, Static Analysis
- Appendix C Best Estimate Concrete, Best Estimate Soil Results, μ=0.0

9.0 CALCULATION REVIEW CHECKLIST

Calculation Review Checklist

Yes	No	N/A	
X			1. Objective is clearly stated.
X			2. Design inputs and their sources are clearly identified, including revision and date of the source.
X			3. Assumptions are listed and identified as unverified as appropriate.
X			4. Analytical approach is described and appropriate to satisfy the stated objectives.
X			5. Software used is identified, including revision and workstation used.
X			6. Computer File Listing has been included and completed if software has been used (Separate listing for each program and version used).
X			7. Results are technically correct and consistent with design input and assumptions.
X			8. Calculations are sufficiently detailed that a technically qualified person can understand and verify the methodology without requiring outside or unreferenced information.
X			9. Results and conclusions address all points in the objective.
X			10. Each page in body of calculation identifies the calculation number, page number, preparer and checker. (Preparer and Checker have signed or initialed each page)
X			11. Each page in appendices or attachments identifies the calculation number and page number, and the first page identifies the preparer and checker. (Preparer and Checker have signed or initialed first page)
X			12. Total number of pages, including attachments or appendices has been included
		X	13. Alternate calculations, if used by the checker, have been included.
		X	14. Revised information has been clearly identified by use of markers such as clouds or revision bars, and a revision history included that describes the changes made and identifies pages changed.

Appendix A

ANSYS Input File Listing

COMMON ANSYS FILES

All-Forces.txt

```
/input,force-c,txt
/input,stress-Primary,txt
/input,Force-J_bolt,txt
!/input,strain-liner,txt
```

Contact-AY.txt

```
!/input,contact-footing,txt
!/input,contact-insul,txt
/input,contact-j-bolts,txt
!/input,contact-primary,txt
!/input,contact-soil,txt
!/input,contact-waste-ay,txt
!/input,waste-reaction,txt
```

Contact-J-Bolts.txt

```
/post26
numvar,200
*do,z,2,200
VARDEL,z
*enddo

*do,i,1,20
*do,j,1,9
angley=-arcsize*(i-1)
esel,s,type,,35
nsle
nsel,r,loc,y,angley,angley-arcsize
nsel,r,loc,x,ptx(j+1),ptx(j+2)
nsel,r,loc,z,ptz(j+1),ptz(j+2)
esln,r,1
*get,emax,elem,,num,max
esol,(2+j),(emax),,cont,pres,pr%(emax)%
esol,(32+j),(emax),,cont,slide,sl%(emax)%
esol,(62+j),(emax),,cont,gap,gap%(emax)%
esol,(92+j),(emax),,cont,stat,stat%(emax)%
esol,(122+j),(emax),,cont,sfric,sf%(emax)%
*enddo

LINES,2050
extrem
/OUT,J-Bolt-Cont_%(9*i)%max,OUT
extrem,3,200
/OUT

/OUT,J-Bolt-Cont_%(9*i)%th,OUT
*do,k,1,21
PRVAR,2+k,32+k,62+k,92+k.122+k
*enddo
/OUT

*enddo
```

CASE SPECIFIC ANSYS FILES
Mu=0.0

Bolts-Friction.txt

```
pi=acos(-1)                   ! Define PI

!ET,4,BEAM44          ! Rigid Links
!KEYOPT,4,8,111
et,4,BEAM4
keyopt,4,6,1

et,31,combin14,,1
et,32,combin14,,2
et,33,combin14,,3

et,34,targe170
et,35,conta173
!keyopt,35,2,3
keyopt,35,5,3
keyopt,35,9,1
keyopt,35,11,1
!keyopt,35,12,4
r,701,0,0,.025
r,702,0,0,.025
r,703,0,0,.025
r,704,0,0,.025
r,705,0,0,.025
r,706,0,0,.025
r,707,0,0,.025
r,708,0,0,.025
r,709,0,0,.025
r,710,0,0,.025
r,711,0,0,.025

BX=33333/20
BY=33333/20
BZ=22777/10
mp,mu,700,0.001

/COM - Create Rigid Links for J-Bolts
nj_bolt=11

mp,ex,401,4176000
mp,nuxy,401,0.30
mp,dens,401,0
r,401,1,10,10,2.5,2.5
rmore,,1e-3
r,402,1,10,10,2.5,2.5
rmore,,1e-3
r,403,1,10,10,2.5,2.5
rmore,,1e-3
r,404,1,10,10,2.5,2.5
rmore,,1e-3
r,405,1,10,10,2.5,2.5
rmore,,1e-3
r,406,1,10,10,2.5,2.5
rmore,,1e-3
r,407,1,10,10,2.5,2.5
rmore,,1e-3
r,408,1,10,10,2.5,2.5
rmore,,1e-3
r,409,1,10,10,2.5,2.5
rmore,,1e-3
r,410,1,10,10,2.5,2.5
rmore,,1e-3
r,411,1,10,10,2.5,2.5
rmore,,1e-3
r,421,1/2,10,10,2.5,2.5
rmore,,1e-3
r,422,1/2,10,10,2.5,2.5
rmore,,1e-3
r,423,1/2,10,10,2.5,2.5
rmore,,1e-3
r,424,1/2,10,10,2.5,2.5
rmore,,1e-3
r,425,1/2,10,10,2.5,2.5
rmore,,1e-3
r,426,1/2,10,10,2.5,2.5
rmore,,1e-3
r,427,1/2,10,10,2.5,2.5
rmore,,1e-3
r,428,1/2,10,10,2.5,2.5
rmore,,1e-3
r,429,1/2,10,10,2.5,2.5
rmore,,1e-3
r,430,1/2,10,10,2.5,2.5
rmore,,1e-3
r,431,1/2,10,10,2.5,2.5
rmore,,1e-3

r,501,1.364*BX
r,502,0.550*BX
r,503,0.887*BX
r,504,1.027*BX
r,505,1.971*BX
r,506,2.407*BX
r,507,3.301*BX
r,508,4.039*BX
r,509,4.369*BX
r,510,5.362*BX
r,511,3.596*BX

r,521,1.364*BY
r,522,0.550*BY
r,523,0.887*BY
r,524,1.027*BY
r,525,1.971*BY
r,526,2.407*BY
r,527,3.301*BY
r,528,4.039*BY
r,529,4.369*BY
r,530,5.362*BY
r,531,3.596*BY

r,541,1.364*BZ
r,542,0.550*BZ
r,543,0.887*BZ
r,544,1.027*BZ
r,545,1.971*BZ
r,546,2.407*BZ
r,547,3.301*BZ
r,548,4.039*BZ
r,549,4.369*BZ
r,550,5.362*BZ
r,551,3.596*BZ

R,601,1.364*BX/2
R,602,0.550*BX/2
R,603,0.887*BX/2
R,604,1.027*BX/2
R,605,1.971*BX/2
R,606,2.407*BX/2
R,607,3.301*BX/2
R,608,4.039*BX/2
R,609,4.369*BX/2
R,610,5.362*BX/2
R,611,3.596*BX/2
```

```
R,621,1.364*BY/2
R,622,0.550*BY/2
R,623,0.887*BY/2
R,624,1.027*BY/2
R,625,1.971*BY/2
R,626,2.407*BY/2
R,627,3.301*BY/2
R,628,4.039*BY/2
R,629,4.369*BY/2
R,630,5.362*BY/2
R,631,3.596*BY/2

R,641,1.364*BZ/2
R,642,0.550*BZ/2
R,643,0.887*BZ/2
R,644,1.027*BZ/2
R,645,1.971*BZ/2
R,646,2.407*BZ/2
R,647,3.301*BZ/2
R,648,4.039*BZ/2
R,649,4.369*BZ/2
R,650,5.362*BZ/2
R,651,3.596*BZ/2

cmsel,s,primary-tank
nsle
nsel,r,loc,z,ptz(1),ptz(11)
cm,bolt-primary-n,node
nsel,none
n,,0,0,ptz(1)
*do,i,2,nj_bolt
*do,j,0,180/arcsize
angley=-j*arcsize
n,,ptx(i),angley,ptz(i)
*enddo
*enddo
cm,bolt-node,node


/COM - Create link at top center of tanks
type,4
mat,401
real,401

nsel,s,loc,x,0                          !
Select nodes on model origin
nsel,r,loc,z,ptz(1),ctz(1)              !
Reselect nodes on concrete and primary
tanks
!nsel,u,node,,1
cmsel,u,bolt-primary-n
eintf,100                               !
Place link at dome center

csys,1
/COM - Create links for J-Bolts
*do,i,2,nj_bolt
       ! Cycle by radius
REAL,400+i
*do,j,1,180/arcsize-1                   !
Cycle by model slice
angley=-j*arcsize                       !
Define angle for node selection
nsel,s,loc,x,ctx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,angley                     !
Reselect nodes at angle "anlgey"
cmsel,u,bolt-primary-n
cmsel,u,waste-n
eintf,100                               !
Create rigid link
*enddo
real,420+i
nsel,s,loc,x,ctx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,0                          !
Reselect nodes at angle 0
cmsel,u,bolt-primary-n
cmsel,u,waste-n
eintf,100                               !
Create rigid link
nsel,s,loc,x,ctx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,180                        !
Reselect nodes at angle 180
cmsel,u,bolt-primary-n
cmsel,u,waste-n
eintf,100                               !
Create rigid link

*enddo

esel,s,type,,4
cm,j_bolts,elem
       ! Create component for J-Bolt
rigid links
allsel


/COM - Create link at top center of tanks
nsel,R,loc,x,0                          !
Select nodes on model origin
nsel,r,loc,z,ptz(1),ptz(1)              !
Reselect nodes on concrete and primary
tanks
TYPE,31
REAL,501
eintf                              ! Place
link at dome center
TYPE,32
REAL,521
eintf                              ! Place
link at dome center
TYPE,33
REAL,541
eintf                              ! Place
link at dome center

csys,1
/COM - Create links for J-Bolts
*do,j,0,2
type,31+j
*do,i,2,nj_bolt
       ! Cycle by radius
REAL,500+20*j+i
*do,k,1,180/arcsize-1                   !
Cycle by model slice
angley=-k*arcsize                       !
Define angle for node selection
nsel,s,loc,x,ptx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,angley                     !
Reselect nodes at angle "anlgey"
cmsel,u,waste-n
eintf                              ! Create
rigid link
*enddo
real,600+j*20+i
```

```
nsel,s,loc,x,ptx(i),ptx(i)           !
Select nodes at radius
nsel,r,loc,y,0                       !
Reselect nodes at angle 0
cmsel,u,waste-n
eintf                        ! Create
rigid link
nsel,s,loc,x,ptx(i),ptx(i)           !
Select nodes at radius
nsel,r,loc,y,180                     !
Reselect nodes at angle 180
cmsel,u,waste-n
eintf                        ! Create
rigid link

*enddo
*enddo

esel,s,type,,31,33
cm,bolt-springs,elem

*do,i,2,10
cmsel,s,conc-tank
nsle
nsel,r,loc,x,ctx(i),ctx(i+1)
nsel,r,loc,z,ctz(i),ctz(i+1)
esln,r
real,700+i
type,34
esurf,,bottom
cmsel,s,primary-tank
nsle
nsel,r,loc,x,ptx(i),ptx(i+1)
nsel,r,loc,z,ptz(i),ptz(i+1)
esln,r
type,35
real,700+i
mat,700
esurf,,bottom
*enddo
esel,s,type,,35
cm,bolt-friction,elem

!*do,i,3,nj_bolt
!cmsel,s,primary-tank
!cmsel,a,conc-tank
!nsle
!nsel,r,loc,z,ptz(i),ctz(i)
!nsel,r,loc,x,ptx(i),ctx(i)
!type,35
!mat,700
!real,700
!eintf,1,high
!*enddo

*get,KMAXjb,KP,0,num,max       ! Get
maximum keypoint number
*get,LMAXjb,LINE,0,num,max     ! Get
maximum line number
*get,AMAXjb,AREA,0,num,max     ! Get
maximum area number
*get,VMAXjb,volu,0,num,max     ! Get
maximum volume number
```

Run-Tank.txt

```
/batch

! PNNL DST Seismic Analysis, Gravity
Inputs, Best Est Soil, Best Est Concrete
Properties, AP Primary Tank Geometry,
Dome Friction=0.0
!
fini
/clear
/filname,BES-BEC-Mu-000-L,1
/config,nres,3000              ! Increase
allowable number of results to 3000
/config,nproc,2                          !
Activate 2 processers for solution
/config,fsplit,1024            ! Split
binary file at 4.2GB
/prep7
g=32.2                         ! Gravity
(ft/sec)

DF=40                          ! Factor
for beta (stiffness) damping
ALPHA=0.4                      ! Alpha
damping

/out,tank-out,out
/sys,"X:\07.00 - Quality Assurance\ANSYS
QA\usrcfg.bat" > QA.out
/out,QA,out,,append
/input,tank-coordinates-AY,txt       !
Run file defining tank coordinates
(concrete and primary)
/input,tank-props-BEC-250,txt ! Run file
defining fully cracked concrete
properties (PNNL Concrete Properties)
/input,tank-mesh1,txt          ! Develop
concrete tank
/input,primary-props-AY,txt   ! Run file
defining AP Primary tank properties
/input,primary,txt             ! Develop
Primary tank
/input,insulate,txt            ! Develop
insulating concrete model
/input,liner,txt               ! Develop
Liner model
/input,waste-solid-AY,txt      ! Develop
waste model
/input,bolts-friction,txt      ! Develop
J-Bolt model
/input,near-soil-1,txt         ! Develop
excavated soil model

/input,far-soil,txt            ! Develop
Far-Field soil model
/input,interface1,txt          ! Develop
Soil and Concrete Interfaces
/input,interface-gap1,txt      ! Develop
Primary Tank Interfaces
/input,slave,txt               ! Develop
slaved boundary conditions
/input,boundary,txt            ! Place
base and symmetry boundary conditions
/input,outer-spar,txt          ! Connect
soil model to symmetry plane
/input,live_load,txt           ! Apply
live load over a 10ft radius over dome
center
/input,fix-soil,txt
/out
ALLSEL

/out,Tank-th,out
```

```
save



/input,solve-Gravity-BES,txt          !
Run solution Phase
/input,contact-AY,txt          ! Extract
Contact data
/input,all-forces,txt          ! Extract
component forces/strains
/out
/exit
```

Solve-Gravity-BES.txt

```
/prep7
massm_z=148414.59
d,master_node,all
allsel

cmsel,s,excav-soil
nsle
csys,0
nsel,r,loc,x,-ctx(6)-1,ctx(6)+1
nsel,r,loc,y,0,-ctx(6)-1
esln,r,1
mpchg,810,all

cmsel,s,excav-soil
nsle
csys,1
nsel,r,loc,x,ctx(11)-1,ctx(13)+1
nsel,r,loc,z,soilz(1),soilz(3)-1
esln,r,1
mpchg,810,all

*do,i,801,808
esel,s,mat,,i
mpchg,i+10,all
*enddo
allsel

/out,BEC-BES-Gravity-Dome-F-000-L,out
/solu
antype,trans
TRNOPT,FULL
lumpm,OFF
!nlgeom,on
NROPT,auto
NTIM=10 !NUMBER OF TIME STEPS
DT=0.01
TIM=1e-06
autots,on
KBC,on
TIMINT,ON,STRU
solcontrol,ON,off,,
ncnv,0,200
LNSRCH,OFF
PRED,on,,on

/COM - Time File

/COM - Dimension Horizontal Input
*DIM,A_1_x,,2048
*DIM,A_1_Z,,2048

*VREAD,A_1_x(1),th-266-Mean-geo,txt
(8(F9.6))
*VREAD,A_1_Z(1),th-266-Mean-geo-v,txt
(8(F9.6))

/Title,Load Case: BES-BEC, Gravity, Dome
Friction =0.00, 0.05g Lateral Accel
OUTPR,all,NONE,
OUTRES, ALL,NONE,
OUTRES,RSOL,last
OUTRES,NSOL,last
OUTRES,ESOL,last,conc-tank
OUTRES,strs,last,Primary-tank
OUTRES,ESOL,last,J_bolts
OUTRES,Epel,last,liner
outres,esol,last,wall-int-gap
outres,esol,last,conc-excav-wall-gap
outres,esol,last,conc-excav-dome-gap
outres,strs,last,excav-soil
outres,strs,last,bottom-soil
outres,esol,last,bolt-friction
outres,esol,last,waste-surf
outres,strs,last,insul-conc
outres,esol,last,primary-int-gap
outres,esol,last,conc-liner-gap
outres,esol,last,far-soil-contact
outres,esol,last,soil-contact-foot-elem

alphad,alpha
NSUBST,20,200,5,ON
TIME,100
TIMINT,off
acel,0.05*g,0,g
SOLVE
SAVE
TIMINT,on
ITIM=1
DS=TIM
NSUBST,1,20,1,ON

!ddele,master_node,ux
!ddele,master_node,uz

esel,s,type,,61,63,2
mpchg,64,all

esel,s,type,,91,93,2
mpchg,92,all

allsel

*DO,ITIM,1,NTIM,1

TIM=DT*ITIM

TIME,TIM+100

F,master_node,FX,A_1_X(itim)*mass*g
F,master_node,Fz,(A_1_Z(itim)+1)*(mass+ma
ssm_z)*g

SOLVE
SAVE
*ENDDO
FINISH
/out
```

Mu=0.1

Bolts-Friction.txt

```
pi=acos(-1)                    ! Define PI

!ET,4,BEAM44           ! Rigid Links
!KEYOPT,4,8,111
et,4,BEAM4
keyopt,4,6,1

et,31,combin14,,1
et,32,combin14,,2
et,33,combin14,,3

et,34,targe170
et,35,conta173
!keyopt,35,2,3
keyopt,35,5,3
keyopt,35,9,1
keyopt,35,11,1
!keyopt,35,12,4
r,701,0,0,.025
r,702,0,0,.025
r,703,0,0,.025
r,704,0,0,.025
r,705,0,0,.025
r,706,0,0,.025
r,707,0,0,.025
r,708,0,0,.025
r,709,0,0,.025
r,710,0,0,.025
r,711,0,0,.025

BX=33333/20
BY=33333/20
BZ=22777/10
mp,mu,700,0.1

/COM - Create Rigid Links for J-Bolts
nj_bolt=11

mp,ex,401,4176000
mp,nuxy,401,0.30
mp,dens,401,0
r,401,1,10,10,2.5,2.5
rmore,,1e-3
r,402,1,10,10,2.5,2.5
rmore,,1e-3
r,403,1,10,10,2.5,2.5
rmore,,1e-3
r,404,1,10,10,2.5,2.5
rmore,,1e-3
r,405,1,10,10,2.5,2.5
rmore,,1e-3
r,406,1,10,10,2.5,2.5
rmore,,1e-3
r,407,1,10,10,2.5,2.5
rmore,,1e-3
r,408,1,10,10,2.5,2.5
rmore,,1e-3
r,409,1,10,10,2.5,2.5
rmore,,1e-3
r,410,1,10,10,2.5,2.5
rmore,,1e-3
r,411,1,10,10,2.5,2.5
rmore,,1e-3
r,421,1/2,10,10,2.5,2.5
rmore,,1e-3
r,422,1/2,10,10,2.5,2.5
rmore,,1e-3
r,423,1/2,10,10,2.5,2.5
rmore,,1e-3
r,424,1/2,10,10,2.5,2.5
rmore,,1e-3
r,425,1/2,10,10,2.5,2.5
rmore,,1e-3
r,426,1/2,10,10,2.5,2.5
rmore,,1e-3
r,427,1/2,10,10,2.5,2.5
rmore,,1e-3
r,428,1/2,10,10,2.5,2.5
rmore,,1e-3
r,429,1/2,10,10,2.5,2.5
rmore,,1e-3
r,430,1/2,10,10,2.5,2.5
rmore,,1e-3
r,431,1/2,10,10,2.5,2.5
rmore,,1e-3

r,501,1.364*BX
r,502,0.550*BX
r,503,0.887*BX
r,504,1.027*BX
r,505,1.971*BX
r,506,2.407*BX
r,507,3.301*BX
r,508,4.039*BX
r,509,4.369*BX
r,510,5.362*BX
r,511,3.596*BX

r,521,1.364*BY
r,522,0.550*BY
r,523,0.887*BY
r,524,1.027*BY
r,525,1.971*BY
r,526,2.407*BY
r,527,3.301*BY
r,528,4.039*BY
r,529,4.369*BY
r,530,5.362*BY
r,531,3.596*BY

r,541,1.364*BZ
r,542,0.550*BZ
r,543,0.887*BZ
r,544,1.027*BZ
r,545,1.971*BZ
r,546,2.407*BZ
r,547,3.301*BZ
r,548,4.039*BZ
r,549,4.369*BZ
r,550,5.362*BZ
r,551,3.596*BZ

R,601,1.364*BX/2
R,602,0.550*BX/2
R,603,0.887*BX/2
R,604,1.027*BX/2
R,605,1.971*BX/2
R,606,2.407*BX/2
R,607,3.301*BX/2
R,608,4.039*BX/2
R,609,4.369*BX/2
R,610,5.362*BX/2
R,611,3.596*BX/2
```

```
R,621,1.364*BY/2
R,622,0.550*BY/2
R,623,0.887*BY/2
R,624,1.027*BY/2
R,625,1.971*BY/2
R,626,2.407*BY/2
R,627,3.301*BY/2
R,628,4.039*BY/2
R,629,4.369*BY/2
R,630,5.362*BY/2
R,631,3.596*BY/2

R,641,1.364*BZ/2
R,642,0.550*BZ/2
R,643,0.887*BZ/2
R,644,1.027*BZ/2
R,645,1.971*BZ/2
R,646,2.407*BZ/2
R,647,3.301*BZ/2
R,648,4.039*BZ/2
R,649,4.369*BZ/2
R,650,5.362*BZ/2
R,651,3.596*BZ/2

cmsel,s,primary-tank
nsle
nsel,r,loc,z,ptz(1),ptz(11)
cm,bolt-primary-n,node
nsel,none
n,,0,0,ptz(1)
*do,i,2,nj_bolt
*do,j,0,180/arcsize
angley=-j*arcsize
n,,ptx(i),angley,ptz(i)
*enddo
*enddo
cm,bolt-node,node


/COM - Create link at top center of tanks
type,4
mat,401
real,401

nsel,s,loc,x,0                          !
Select nodes on model origin
nsel,r,loc,z,ptz(1),ctz(1)              !
Reselect nodes on concrete and primary
tanks
!nsel,u,node,,1
cmsel,u,bolt-primary-n
eintf,100                               !
Place link at dome center

csys,1
/COM - Create links for J-Bolts
*do,i,2,nj_bolt
        ! Cycle by radius
REAL,400+i
*do,j,1,180/arcsize-1                   !
Cycle by model slice
angley=-j*arcsize                       !
Define angle for node selection
nsel,s,loc,x,ctx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,angley                     !
Reselect nodes at angle "anlgey"
cmsel,u,bolt-primary-n
cmsel,u,waste-n
```

```
eintf,100                               !
Create rigid link
*enddo
real,420+i
nsel,s,loc,x,ctx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,0                          !
Reselect nodes at angle 0
cmsel,u,bolt-primary-n
cmsel,u,waste-n
eintf,100                               !
Create rigid link
nsel,s,loc,x,ctx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,180                        !
Reselect nodes at angle 180
cmsel,u,bolt-primary-n
cmsel,u,waste-n
eintf,100                               !
Create rigid link

*enddo

esel,s,type,,4
cm,j_bolts,elem
        ! Create component for J-Bolt
rigid links
allsel


/COM - Create link at top center of tanks
nsel,R,loc,x,0                          !
Select nodes on model origin
nsel,r,loc,z,ptz(1),ptz(1)              !
Reselect nodes on concrete and primary
tanks
TYPE,31
REAL,501
eintf                              ! Place
link at dome center
TYPE,32
REAL,521
eintf                              ! Place
link at dome center
TYPE,33
REAL,541
eintf                              ! Place
link at dome center

csys,1
/COM - Create links for J-Bolts
*do,j,0,2
type,31+j
*do,i,2,nj_bolt
        ! Cycle by radius
REAL,500+20*j+i
*do,k,1,180/arcsize-1                   !
Cycle by model slice
angley=-k*arcsize                       !
Define angle for node selection
nsel,s,loc,x,ptx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,angley                     !
Reselect nodes at angle "anlgey"
cmsel,u,waste-n
eintf                              ! Create
rigid link
*enddo
real,600+j*20+i
```

```
nsel,s,loc,x,ptx(i),ptx(i)           !
Select nodes at radius
nsel,r,loc,y,0                       !
Reselect nodes at angle 0
cmsel,u,waste-n
eintf                        ! Create
rigid link
nsel,s,loc,x,ptx(i),ptx(i)           !
Select nodes at radius
nsel,r,loc,y,180                     !
Reselect nodes at angle 180
cmsel,u,waste-n
eintf                        ! Create
rigid link

*enddo
*enddo

esel,s,type,,31,33
cm,bolt-springs,elem

*do,i,2,10
cmsel,s,conc-tank
nsle
nsel,r,loc,x,ctx(i),ctx(i+1)
nsel,r,loc,z,ctz(i),ctz(i+1)
esln,r
real,700+i
type,34
esurf,,bottom
cmsel,s,primary-tank
nsle
nsel,r,loc,x,ptx(i),ptx(i+1)
nsel,r,loc,z,ptz(i),ptz(i+1)
esln,r
type,35
real,700+i
mat,700
esurf,,bottom
*enddo
esel,s,type,,35
cm,bolt-friction,elem

!*do,i,3,nj_bolt
!cmsel,s,primary-tank
!cmsel,a,conc-tank
!nsle
!nsel,r,loc,z,ptz(i),ctz(i)
!nsel,r,loc,x,ptx(i),ctx(i)
!type,35
!mat,700
!real,700
!eintf,1,high
!*enddo

*get,KMAXjb,KP,0,num,max       ! Get
maximum keypoint number
*get,LMAXjb,LINE,0,num,max     ! Get
maximum line number
*get,AMAXjb,AREA,0,num,max     ! Get
maximum area number
*get,VMAXjb,volu,0,num,max     ! Get
maximum volume number
```

Run-Tank.txt

```
/batch

! PNNL DST Seismic Analysis, Gravity
Inputs, Best Est Soil, Best Est Concrete
Properties, AP Primary Tank Geometry,
Dome Friction=0.1
!
fini
/clear
/filname,BES-BEC-Mu-010-L,1
/config,nres,3000              ! Increase
allowable number of results to 3000
/config,nproc,2                          !
Activate 2 processers for solution
/config,fsplit,1024            ! Split
binary file at 4.2GB
/prep7
g=32.2                         ! Gravity
(ft/sec)

DF=40                          ! Factor
for beta (stiffness) damping
ALPHA=0.4                      ! Alpha
damping

/out,tank-out,out
/sys,"X:\07.00 - Quality Assurance\ANSYS
QA\usrcfg.bat" > QA.out
/out,QA,out,,append
/input,tank-coordinates-AY,txt        !
Run file defining tank coordinates
(concrete and primary)
/input,tank-props-BEC-250,txt ! Run file
defining fully cracked concrete
properties (PNNL Concrete Properties)
/input,tank-mesh1,txt          ! Develop
concrete tank
/input,primary-props-AY,txt   ! Run file
defining AP Primary tank properties
/input,primary,txt             ! Develop
Primary tank
/input,insulate,txt            ! Develop
insulating concrete model
/input,liner,txt               ! Develop
Liner model
/input,waste-solid-AY,txt      ! Develop
waste model
/input,bolts-friction,txt      ! Develop
J-Bolt model
/input,near-soil-1,txt         ! Develop
excavated soil model

/input,far-soil,txt            ! Develop
Far-Field soil model
/input,interface1,txt          ! Develop
Soil and Concrete Interfaces
/input,interface-gap1,txt      ! Develop
Primary Tank Interfaces
/input,slave,txt               ! Develop
slaved boundary conditions
/input,boundary,txt            ! Place
base and symmetry boundary conditions
/input,outer-spar,txt          ! Connect
soil model to symmetry plane
/input,live_load,txt           ! Apply
live load over a 10ft radius over dome
center
/input,fix-soil,txt
/out
ALLSEL

/out,Tank-th,out
```

```
save



/input,solve-Gravity-BES,txt          !
Run solution Phase
/input,contact-AY,txt         ! Extract
Contact data
/input,all-forces,txt         ! Extract
component forces/strains
/out
/exit
```

Solve-Gravity-BES.txt

```
/prep7
massm_z=148414.59
d,master_node,all
allsel

cmsel,s,excav-soil
nsle
csys,0
nsel,r,loc,x,-ctx(6)-1,ctx(6)+1
nsel,r,loc,y,0,-ctx(6)-1
esln,r,1
mpchg,810,all

cmsel,s,excav-soil
nsle
csys,1
nsel,r,loc,x,ctx(11)-1,ctx(13)+1
nsel,r,loc,z,soilz(1),soilz(3)-1
esln,r,1
mpchg,810,all

*do,i,801,808
esel,s,mat,,i
mpchg,i+10,all
*enddo
allsel

/out,BEC-BES-Gravity-Dome-F-010-L,out
/solu
antype,trans
TRNOPT,FULL
lumpm,OFF
!nlgeom,on
NROPT,auto
NTIM=10 !NUMBER OF TIME STEPS
DT=0.01
TIM=1e-06
autots,on
KBC,on
TIMINT,ON,STRU
solcontrol,ON,off,,
ncnv,0,200
LNSRCH,OFF
PRED,on,,on

/COM - Time File

/COM - Dimension Horizontal Input
*DIM,A_1_x,,2048
*DIM,A_1_Z,,2048

*VREAD,A_1_x(1),th-266-Mean-geo,txt
(8(F9.6))
*VREAD,A_1_Z(1),th-266-Mean-geo-v,txt
(8(F9.6))

/Title,Load Case: BES-BEC, Gravity, Dome
Friction =0.10, 0.05g Lateral Accel
OUTPR,all,NONE,
OUTRES, ALL,NONE,
OUTRES,RSOL,last
OUTRES,NSOL,last
OUTRES,ESOL,last,conc-tank
OUTRES,strs,last,Primary-tank
OUTRES,ESOL,last,J_bolts
OUTRES,Epel,last,liner
outres,esol,last,wall-int-gap
outres,esol,last,conc-excav-wall-gap
outres,esol,last,conc-excav-dome-gap
outres,strs,last,excav-soil
outres,strs,last,bottom-soil
outres,esol,last,bolt-friction
outres,esol,last,waste-surf
outres,strs,last,insul-conc
outres,esol,last,primary-int-gap
outres,esol,last,conc-liner-gap
outres,esol,last,far-soil-contact
outres,esol,last,soil-contact-foot-elem

alphad,alpha
NSUBST,20,200,5,ON
TIME,100
TIMINT,off
acel,0.05*g,0,g
SOLVE
SAVE
TIMINT,on
ITIM=1
DS=TIM
NSUBST,1,20,1,ON

!ddele,master_node,ux
!ddele,master_node,uz

esel,s,type,,61,63,2
mpchg,64,all

esel,s,type,,91,93,2
mpchg,92,all

allsel

*DO,ITIM,1,NTIM,1

TIM=DT*ITIM

TIME,TIM+100

F,master_node,FX,A_1_X(itim)*mass*g
F,master_node,Fz,(A_1_Z(itim)+1)*(mass+ma
ssm_z)*g

SOLVE
SAVE
*ENDDO
FINISH
/out
```

Mu=0.2

Bolts-Friction.txt

```
pi=acos(-1)                        ! Define PI

!ET,4,BEAM44            ! Rigid Links
!KEYOPT,4,8,111
et,4,BEAM4
keyopt,4,6,1

et,31,combin14,,1
et,32,combin14,,2
et,33,combin14,,3

et,34,targe170
et,35,conta173
!keyopt,35,2,3
keyopt,35,5,3
keyopt,35,9,1
keyopt,35,11,1
!keyopt,35,12,4
r,701,0,0,.025
r,702,0,0,.025
r,703,0,0,.025
r,704,0,0,.025
r,705,0,0,.025
r,706,0,0,.025
r,707,0,0,.025
r,708,0,0,.025
r,709,0,0,.025
r,710,0,0,.025
r,711,0,0,.025

BX=33333/20
BY=33333/20
BZ=22777/10
mp,mu,700,0.20

/COM - Create Rigid Links for J-Bolts
nj_bolt=11

mp,ex,401,4176000
mp,nuxy,401,0.30
mp,dens,401,0
r,401,1,10,10,2.5,2.5
rmore,,1e-3
r,402,1,10,10,2.5,2.5
rmore,,1e-3
r,403,1,10,10,2.5,2.5
rmore,,1e-3
r,404,1,10,10,2.5,2.5
rmore,,1e-3
r,405,1,10,10,2.5,2.5
rmore,,1e-3
r,406,1,10,10,2.5,2.5
rmore,,1e-3
r,407,1,10,10,2.5,2.5
rmore,,1e-3
r,408,1,10,10,2.5,2.5
rmore,,1e-3
r,409,1,10,10,2.5,2.5
rmore,,1e-3
r,410,1,10,10,2.5,2.5
rmore,,1e-3
r,411,1,10,10,2.5,2.5
rmore,,1e-3

r,421,1/2,10,10,2.5,2.5
rmore,,1e-3
r,422,1/2,10,10,2.5,2.5
rmore,,1e-3
r,423,1/2,10,10,2.5,2.5
rmore,,1e-3
r,424,1/2,10,10,2.5,2.5
rmore,,1e-3
r,425,1/2,10,10,2.5,2.5
rmore,,1e-3
r,426,1/2,10,10,2.5,2.5
rmore,,1e-3
r,427,1/2,10,10,2.5,2.5
rmore,,1e-3
r,428,1/2,10,10,2.5,2.5
rmore,,1e-3
r,429,1/2,10,10,2.5,2.5
rmore,,1e-3
r,430,1/2,10,10,2.5,2.5
rmore,,1e-3
r,431,1/2,10,10,2.5,2.5
rmore,,1e-3

r,501,1.364*BX
r,502,0.550*BX
r,503,0.887*BX
r,504,1.027*BX
r,505,1.971*BX
r,506,2.407*BX
r,507,3.301*BX
r,508,4.039*BX
r,509,4.369*BX
r,510,5.362*BX
r,511,3.596*BX

r,521,1.364*BY
r,522,0.550*BY
r,523,0.887*BY
r,524,1.027*BY
r,525,1.971*BY
r,526,2.407*BY
r,527,3.301*BY
r,528,4.039*BY
r,529,4.369*BY
r,530,5.362*BY
r,531,3.596*BY

r,541,1.364*BZ
r,542,0.550*BZ
r,543,0.887*BZ
r,544,1.027*BZ
r,545,1.971*BZ
r,546,2.407*BZ
r,547,3.301*BZ
r,548,4.039*BZ
r,549,4.369*BZ
r,550,5.362*BZ
r,551,3.596*BZ

R,601,1.364*BX/2
R,602,0.550*BX/2
R,603,0.887*BX/2
R,604,1.027*BX/2
R,605,1.971*BX/2
R,606,2.407*BX/2
R,607,3.301*BX/2
R,608,4.039*BX/2
R,609,4.369*BX/2
R,610,5.362*BX/2
R,611,3.596*BX/2

R,621,1.364*BY/2
```

```
R,622,0.550*BY/2
R,623,0.887*BY/2
R,624,1.027*BY/2
R,625,1.971*BY/2
R,626,2.407*BY/2
R,627,3.301*BY/2
R,628,4.039*BY/2
R,629,4.369*BY/2
R,630,5.362*BY/2
R,631,3.596*BY/2

R,641,1.364*BZ/2
R,642,0.550*BZ/2
R,643,0.887*BZ/2
R,644,1.027*BZ/2
R,645,1.971*BZ/2
R,646,2.407*BZ/2
R,647,3.301*BZ/2
R,648,4.039*BZ/2
R,649,4.369*BZ/2
R,650,5.362*BZ/2
R,651,3.596*BZ/2

cmsel,s,primary-tank
nsle
nsel,r,loc,z,ptz(1),ptz(11)
cm,bolt-primary-n,node
nsel,none
n,,0,0,ptz(1)
*do,i,2,nj_bolt
*do,j,0,180/arcsize
angley=-j*arcsize
n,,ptx(i),angley,ptz(i)
*enddo
*enddo
cm,bolt-node,node


/COM - Create link at top center of tanks
type,4
mat,401
real,401

nsel,s,loc,x,0                          !
Select nodes on model origin
nsel,r,loc,z,ptz(1),ctz(1)              !
Reselect nodes on concrete and primary
tanks
!nsel,u,node,,1
cmsel,u,bolt-primary-n
eintf,100                               !
Place link at dome center

csys,1
/COM - Create links for J-Bolts
*do,i,2,nj_bolt
       ! Cycle by radius
REAL,400+i
*do,j,1,180/arcsize-1                   !
Cycle by model slice
angley=-j*arcsize                       !
Define angle for node selection
nsel,s,loc,x,ctx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,angley                     !
Reselect nodes at angle "anlgey"
cmsel,u,bolt-primary-n
cmsel,u,waste-n
eintf,100                               !
Create rigid link
*enddo
real,420+i
nsel,s,loc,x,ctx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,0                          !
Reselect nodes at angle 0
cmsel,u,bolt-primary-n
cmsel,u,waste-n
eintf,100                               !
Create rigid link
nsel,s,loc,x,ctx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,180                        !
Reselect nodes at angle 180
cmsel,u,bolt-primary-n
cmsel,u,waste-n
eintf,100                               !
Create rigid link

*enddo

esel,s,type,,4
cm,j_bolts,elem
       ! Create component for J-Bolt
rigid links
allsel


/COM - Create link at top center of tanks
nsel,R,loc,x,0                          !
Select nodes on model origin
nsel,r,loc,z,ptz(1),ptz(1)              !
Reselect nodes on concrete and primary
tanks
TYPE,31
REAL,501
eintf                         ! Place
link at dome center
TYPE,32
REAL,521
eintf                         ! Place
link at dome center
TYPE,33
REAL,541
eintf                         ! Place
link at dome center

csys,1
/COM - Create links for J-Bolts
*do,j,0,2
type,31+j
*do,i,2,nj_bolt
       ! Cycle by radius
REAL,500+20*j+i
*do,k,1,180/arcsize-1                   !
Cycle by model slice
angley=-k*arcsize                       !
Define angle for node selection
nsel,s,loc,x,ptx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,angley                     !
Reselect nodes at angle "anlgey"
cmsel,u,waste-n
eintf                         ! Create
rigid link
*enddo
real,600+j*20+i
nsel,s,loc,x,ptx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,0                          !
Reselect nodes at angle 0
```

```
cmsel,u,waste-n
eintf                          ! Create
rigid link
nsel,s,loc,x,ptx(i),ptx(i)             !
Select nodes at radius
nsel,r,loc,y,180                       !
Reselect nodes at angle 180
cmsel,u,waste-n
eintf                          ! Create
rigid link

*enddo
*enddo

esel,s,type,,31,33
cm,bolt-springs,elem

*do,i,2,10
cmsel,s,conc-tank
nsle
nsel,r,loc,x,ctx(i),ctx(i+1)
nsel,r,loc,z,ctz(i),ctz(i+1)
esln,r
real,700+i
type,34
esurf,,bottom
cmsel,s,primary-tank
nsle
nsel,r,loc,x,ptx(i),ptx(i+1)
nsel,r,loc,z,ptz(i),ptz(i+1)
esln,r
type,35
real,700+i
mat,700
esurf,,bottom
*enddo
esel,s,type,,35
cm,bolt-friction,elem

!*do,i,3,nj_bolt
!cmsel,s,primary-tank
!cmsel,a,conc-tank
!nsle
!nsel,r,loc,z,ptz(i),ctz(i)
!nsel,r,loc,x,ptx(i),ctx(i)
!type,35
!mat,700
!real,700
!eintf,1,high
!*enddo

*get,KMAXjb,KP,0,num,max       ! Get
maximum keypoint number
*get,LMAXjb,LINE,0,num,max     ! Get
maximum line number
*get,AMAXjb,AREA,0,num,max     ! Get
maximum area number
*get,VMAXjb,volu,0,num,max     ! Get
maximum volume number
```

Run-Tank.txt

```
/batch
! PNNL DST Seismic Analysis, Gravity
Inputs, Best Est Soil, Best Est Concrete
Properties, AP Primary Tank Geometry,
Dome Friction=0.2
!
fini
/clear
/filname,BES-BEC-Mu-020-L,1
/config,nres,3000              ! Increase
allowable number of results to 3000
/config,nproc,2                          !
Activate 2 processers for solution
/config,fsplit,1024            ! Split
binary file at 4.2GB
/prep7
g=32.2                         ! Gravity
(ft/sec)

DF=40                          ! Factor
for beta (stiffness) damping
ALPHA=0.4                      ! Alpha
damping

/out,tank-out,out
/sys,"X:\07.00 - Quality Assurance\ANSYS
QA\usrcfg.bat" > QA.out
/out,QA,out,,append
/input,tank-coordinates-AY,txt         !
Run file defining tank coordinates
(concrete and primary)
/input,tank-props-BEC-250,txt ! Run file
defining fully cracked concrete
properties (PNNL Concrete Properties)
/input,tank-mesh1,txt          ! Develop
concrete tank
/input,primary-props-AY,txt    ! Run file
defining AP Primary tank properties
/input,primary,txt             ! Develop
Primary tank
/input,insulate,txt            ! Develop
insulating concrete model
/input,liner,txt               ! Develop
Liner model
/input,waste-solid-AY,txt      ! Develop
waste model
/input,bolts-friction,txt      ! Develop
J-Bolt model
/input,near-soil-1,txt         ! Develop
excavated soil model

/input,far-soil,txt            ! Develop
Far-Field soil model
/input,interface1,txt          ! Develop
Soil and Concrete Interfaces
/input,interface-gap1,txt      ! Develop
Primary Tank Interfaces
/input,slave,txt               ! Develop
slaved boundary conditions
/input,boundary,txt            ! Place
base and symmetry boundary conditions
/input,outer-spar,txt          ! Connect
soil model to symmetry plane
/input,live_load,txt           ! Apply
live load over a 10ft radius over dome
center
/input,fix-soil,txt
/out
ALLSEL

/out,Tank-th,out

save
```

```
/input,solve-Gravity-BES,txt          !
Run solution Phase
/input,contact-AY,txt         ! Extract
Contact data
/input,all-forces,txt         ! Extract
component forces/strains
/out
/exit
```

Solve-Gravity-BES.txt

```
/prep7
massm_z=148414.59
d,master_node,all
allsel

cmsel,s,excav-soil
nsle
csys,0
nsel,r,loc,x,-ctx(6)-1,ctx(6)+1
nsel,r,loc,y,0,-ctx(6)-1
esln,r,1
mpchg,810,all

cmsel,s,excav-soil
nsle
csys,1
nsel,r,loc,x,ctx(11)-1,ctx(13)+1
nsel,r,loc,z,soilz(1),soilz(3)-1
esln,r,1
mpchg,810,all

*do,i,801,808
esel,s,mat,,i
mpchg,i+10,all
*enddo
allsel

/out,BEC-BES-Gravity-Dome-F-020-L,out
/solu
antype,trans
TRNOPT,FULL
lumpm,OFF
!nlgeom,on
NROPT,auto
NTIM=10 !NUMBER OF TIME STEPS
DT=0.01
TIM=1e-06
autots,on
KBC,on
TIMINT,ON,STRU
solcontrol,ON,off,,
ncnv,0,200
LNSRCH,OFF
PRED,on,,on

/COM - Time File

/COM - Dimension Horizontal Input
*DIM,A_1_x,,2048
*DIM,A_1_Z,,2048

*VREAD,A_1_x(1),th-266-Mean-geo,txt
(8(F9.6))
*VREAD,A_1_Z(1),th-266-Mean-geo-v,txt
(8(F9.6))

/Title,Load Case: BES-BEC, Gravity, Dome
Friction =0.20, 0.05g Lateral Accel
OUTPR,all,NONE,
OUTRES, ALL,NONE,
OUTRES,RSOL,last
OUTRES,NSOL,last
OUTRES,ESOL,last,conc-tank
OUTRES,strs,last,Primary-tank
OUTRES,ESOL,last,J_bolts
OUTRES,Epel,last,liner
outres,esol,last,wall-int-gap
outres,esol,last,conc-excav-wall-gap
outres,esol,last,conc-excav-dome-gap
outres,strs,last,excav-soil
outres,strs,last,bottom-soil
outres,esol,last,bolt-friction
outres,esol,last,waste-surf
outres,strs,last,insul-conc
outres,esol,last,primary-int-gap
outres,esol,last,conc-liner-gap
outres,esol,last,far-soil-contact
outres,esol,last,soil-contact-foot-elem

alphad,alpha
NSUBST,20,200,5,ON
TIME,100
TIMINT,off
acel,0.05*g,0,g
SOLVE
SAVE
TIMINT,on
ITIM=1
DS=TIM
NSUBST,1,20,1,ON

!ddele,master_node,ux
!ddele,master_node,uz

esel,s,type,,61,63,2
mpchg,64,all

esel,s,type,,91,93,2
mpchg,92,all

allsel

*DO,ITIM,1,NTIM,1

TIM=DT*ITIM

TIME,TIM+100

F,master_node,FX,A_1_X(itim)*mass*g
F,master_node,Fz,(A_1_Z(itim)+1)*(mass+ma
ssm_z)*g

SOLVE
SAVE
*ENDDO
FINISH
/out
```

Mu=0.3

Bolts-Friction.txt

```
pi=acos(-1)                    ! Define PI

!ET,4,BEAM44           ! Rigid Links
!KEYOPT,4,8,111
et,4,BEAM4
keyopt,4,6,1

et,31,combin14,,1
et,32,combin14,,2
et,33,combin14,,3

et,34,targe170
et,35,conta173
!keyopt,35,2,3
keyopt,35,5,3
keyopt,35,9,1
keyopt,35,11,1
!keyopt,35,12,4
r,701,0,0,.025
r,702,0,0,.025
r,703,0,0,.025
r,704,0,0,.025
r,705,0,0,.025
r,706,0,0,.025
r,707,0,0,.025
r,708,0,0,.025
r,709,0,0,.025
r,710,0,0,.025
r,711,0,0,.025

BX=33333/20
BY=33333/20
BZ=22777/10
mp,mu,700,0.3

/COM - Create Rigid Links for J-Bolts
nj_bolt=11

mp,ex,401,4176000
mp,nuxy,401,0.30
mp,dens,401,0
r,401,1,10,10,2.5,2.5
rmore,,1e-3
r,402,1,10,10,2.5,2.5
rmore,,1e-3
r,403,1,10,10,2.5,2.5
rmore,,1e-3
r,404,1,10,10,2.5,2.5
rmore,,1e-3
r,405,1,10,10,2.5,2.5
rmore,,1e-3
r,406,1,10,10,2.5,2.5
rmore,,1e-3
r,407,1,10,10,2.5,2.5
rmore,,1e-3
r,408,1,10,10,2.5,2.5
rmore,,1e-3
r,409,1,10,10,2.5,2.5
rmore,,1e-3
r,410,1,10,10,2.5,2.5
rmore,,1e-3
r,411,1,10,10,2.5,2.5
rmore,,1e-3

r,421,1/2,10,10,2.5,2.5
rmore,,1e-3
r,422,1/2,10,10,2.5,2.5
rmore,,1e-3
r,423,1/2,10,10,2.5,2.5
rmore,,1e-3
r,424,1/2,10,10,2.5,2.5
rmore,,1e-3
r,425,1/2,10,10,2.5,2.5
rmore,,1e-3
r,426,1/2,10,10,2.5,2.5
rmore,,1e-3
r,427,1/2,10,10,2.5,2.5
rmore,,1e-3
r,428,1/2,10,10,2.5,2.5
rmore,,1e-3
r,429,1/2,10,10,2.5,2.5
rmore,,1e-3
r,430,1/2,10,10,2.5,2.5
rmore,,1e-3
r,431,1/2,10,10,2.5,2.5
rmore,,1e-3

r,501,1.364*BX
r,502,0.550*BX
r,503,0.887*BX
r,504,1.027*BX
r,505,1.971*BX
r,506,2.407*BX
r,507,3.301*BX
r,508,4.039*BX
r,509,4.369*BX
r,510,5.362*BX
r,511,3.596*BX

r,521,1.364*BY
r,522,0.550*BY
r,523,0.887*BY
r,524,1.027*BY
r,525,1.971*BY
r,526,2.407*BY
r,527,3.301*BY
r,528,4.039*BY
r,529,4.369*BY
r,530,5.362*BY
r,531,3.596*BY

r,541,1.364*BZ
r,542,0.550*BZ
r,543,0.887*BZ
r,544,1.027*BZ
r,545,1.971*BZ
r,546,2.407*BZ
r,547,3.301*BZ
r,548,4.039*BZ
r,549,4.369*BZ
r,550,5.362*BZ
r,551,3.596*BZ

R,601,1.364*BX/2
R,602,0.550*BX/2
R,603,0.887*BX/2
R,604,1.027*BX/2
R,605,1.971*BX/2
R,606,2.407*BX/2
R,607,3.301*BX/2
R,608,4.039*BX/2
R,609,4.369*BX/2
R,610,5.362*BX/2
R,611,3.596*BX/2

R,621,1.364*BY/2
```

```
R,622,0.550*BY/2
R,623,0.887*BY/2
R,624,1.027*BY/2
R,625,1.971*BY/2
R,626,2.407*BY/2
R,627,3.301*BY/2
R,628,4.039*BY/2
R,629,4.369*BY/2
R,630,5.362*BY/2
R,631,3.596*BY/2

R,641,1.364*BZ/2
R,642,0.550*BZ/2
R,643,0.887*BZ/2
R,644,1.027*BZ/2
R,645,1.971*BZ/2
R,646,2.407*BZ/2
R,647,3.301*BZ/2
R,648,4.039*BZ/2
R,649,4.369*BZ/2
R,650,5.362*BZ/2
R,651,3.596*BZ/2

cmsel,s,primary-tank
nsle
nsel,r,loc,z,ptz(1),ptz(11)
cm,bolt-primary-n,node
nsel,none
n,,0,0,ptz(1)
*do,i,2,nj_bolt
*do,j,0,180/arcsize
angley=-j*arcsize
n,,ptx(i),angley,ptz(i)
*enddo
*enddo
cm,bolt-node,node


/COM - Create link at top center of tanks
type,4
mat,401
real,401

nsel,s,loc,x,0                          !
Select nodes on model origin
nsel,r,loc,z,ptz(1),ctz(1)              !
Reselect nodes on concrete and primary
tanks
!nsel,u,node,,1
cmsel,u,bolt-primary-n
eintf,100                               !
Place link at dome center

csys,1
/COM - Create links for J-Bolts
*do,i,2,nj_bolt
        ! Cycle by radius
REAL,400+i
*do,j,1,180/arcsize-1                   !
Cycle by model slice
angley=-j*arcsize                       !
Define angle for node selection
nsel,s,loc,x,ctx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,angley                     !
Reselect nodes at angle "anlgey"
cmsel,u,bolt-primary-n
cmsel,u,waste-n
eintf,100                               !
Create rigid link
*enddo
real,420+i
nsel,s,loc,x,ctx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,0                          !
Reselect nodes at angle 0
cmsel,u,bolt-primary-n
cmsel,u,waste-n
eintf,100                               !
Create rigid link
nsel,s,loc,x,ctx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,180                        !
Reselect nodes at angle 180
cmsel,u,bolt-primary-n
cmsel,u,waste-n
eintf,100                               !
Create rigid link

*enddo

esel,s,type,,4
cm,j_bolts,elem
        ! Create component for J-Bolt
rigid links
allsel


/COM - Create link at top center of tanks
nsel,R,loc,x,0                          !
Select nodes on model origin
nsel,r,loc,z,ptz(1),ptz(1)              !
Reselect nodes on concrete and primary
tanks
TYPE,31
REAL,501
eintf                         ! Place
link at dome center
TYPE,32
REAL,521
eintf                         ! Place
link at dome center
TYPE,33
REAL,541
eintf                         ! Place
link at dome center

csys,1
/COM - Create links for J-Bolts
*do,j,0,2
type,31+j
*do,i,2,nj_bolt
        ! Cycle by radius
REAL,500+20*j+i
*do,k,1,180/arcsize-1                   !
Cycle by model slice
angley=-k*arcsize                       !
Define angle for node selection
nsel,s,loc,x,ptx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,angley                     !
Reselect nodes at angle "anlgey"
cmsel,u,waste-n
eintf                         ! Create
rigid link
*enddo
real,600+j*20+i
nsel,s,loc,x,ptx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,0                          !
Reselect nodes at angle 0
```

```
cmsel,u,waste-n
eintf                           ! Create
rigid link
nsel,s,loc,x,ptx(i),ptx(i)              !
Select nodes at radius
nsel,r,loc,y,180                        !
Reselect nodes at angle 180
cmsel,u,waste-n
eintf                           ! Create
rigid link

*enddo
*enddo

esel,s,type,,31,33
cm,bolt-springs,elem

*do,i,2,10
cmsel,s,conc-tank
nsle
nsel,r,loc,x,ctx(i),ctx(i+1)
nsel,r,loc,z,ctz(i),ctz(i+1)
esln,r
real,700+i
type,34
esurf,,bottom
cmsel,s,primary-tank
nsle
nsel,r,loc,x,ptx(i),ptx(i+1)
nsel,r,loc,z,ptz(i),ptz(i+1)
esln,r
type,35
real,700+i
mat,700
esurf,,bottom
*enddo
esel,s,type,,35
cm,bolt-friction,elem

!*do,i,3,nj_bolt
!cmsel,s,primary-tank
!cmsel,a,conc-tank
!nsle
!nsel,r,loc,z,ptz(i),ctz(i)
!nsel,r,loc,x,ptx(i),ctx(i)
!type,35
!mat,700
!real,700
!eintf,1,high
!*enddo

*get,KMAXjb,KP,0,num,max        ! Get
maximum keypoint number
*get,LMAXjb,LINE,0,num,max      ! Get
maximum line number
*get,AMAXjb,AREA,0,num,max      ! Get
maximum area number
*get,VMAXjb,volu,0,num,max      ! Get
maximum volume number
```

Run-Tank.txt

```
!/batch
! PNNL DST Seismic Analysis, Gravity
Inputs, Best Est Soil, Best Est Concrete
Properties, AP Primary Tank Geometry,
Dome Friction=0.3
!
fini
/clear
/filname,BES-BEC-Mu-030-L,1
/config,nres,3000              ! Increase
allowable number of results to 3000
/config,nproc,2                          !
Activate 2 processers for solution
/config,fsplit,1024            ! Split
binary file at 4.2GB
/prep7
g=32.2                         ! Gravity
(ft/sec)

DF=40                          ! Factor
for beta (stiffness) damping
ALPHA=0.4                      ! Alpha
damping

/out,tank-out,out
/sys,"X:\07.00 - Quality Assurance\ANSYS
QA\usrcfg.bat" > QA.out
/out,QA,out,,append
/input,tank-coordinates-AY,txt        !
Run file defining tank coordinates
(concrete and primary)
/input,tank-props-BEC-250,txt ! Run file
defining fully cracked concrete
properties (PNNL Concrete Properties)
/input,tank-mesh1,txt          ! Develop
concrete tank
/input,primary-props-AY,txt    ! Run file
defining AP Primary tank properties
/input,primary,txt             ! Develop
Primary tank
/input,insulate,txt            ! Develop
insulating concrete model
/input,liner,txt               ! Develop
Liner model
/input,waste-solid-AY,txt      ! Develop
waste model
/input,bolts-friction,txt      ! Develop
J-Bolt model
/input,near-soil-1,txt         ! Develop
excavated soil model

/input,far-soil,txt            ! Develop
Far-Field soil model
/input,interface1,txt          ! Develop
Soil and Concrete Interfaces
/input,interface-gap1,txt      ! Develop
Primary Tank Interfaces
/input,slave,txt               ! Develop
slaved boundary conditions
/input,boundary,txt            ! Place
base and symmetry boundary conditions
/input,outer-spar,txt          ! Connect
soil model to symmetry plane
/input,live_load,txt           ! Apply
live load over a 10ft radius over dome
center
/input,fix-soil,txt
/out
ALLSEL

/out,Tank-th,out

save
```

```
/input,solve-Gravity-BES,txt          !
Run solution Phase
/input,contact-AY,txt          ! Extract
Contact data
/input,all-forces,txt          ! Extract
component forces/strains
/out
!/exit
```

Solve-Gravity-BES.txt

```
/prep7
massm_z=148414.59
d,master_node,all
allsel

cmsel,s,excav-soil
nsle
csys,0
nsel,r,loc,x,-ctx(6)-1,ctx(6)+1
nsel,r,loc,y,0,-ctx(6)-1
esln,r,1
mpchg,810,all

cmsel,s,excav-soil
nsle
csys,1
nsel,r,loc,x,ctx(11)-1,ctx(13)+1
nsel,r,loc,z,soilz(1),soilz(3)-1
esln,r,1
mpchg,810,all

*do,i,801,808
esel,s,mat,,i
mpchg,i+10,all
*enddo
allsel

/out,BEC-BES-Gravity-Dome-F-030-L,out
/solu
antype,trans
TRNOPT,FULL
lumpm,OFF
!nlgeom,on
NROPT,auto
NTIM=10 !NUMBER OF TIME STEPS
DT=0.01
TIM=1e-06
autots,on
KBC,on
TIMINT,ON,STRU
solcontrol,ON,off,,
ncnv,0,200
LNSRCH,OFF
PRED,on,,on

/COM - Time File

/COM - Dimension Horizontal Input
*DIM,A_1_x,,2048
*DIM,A_1_Z,,2048

*VREAD,A_1_x(1),th-266-Mean-geo,txt
(8(F9.6))
*VREAD,A_1_Z(1),th-266-Mean-geo-v,txt
(8(F9.6))

/Title,Load Case: BES-BEC, Gravity, Dome
Friction =0.30, 0.05g Lateral Accel
OUTPR,all,NONE,
OUTRES, ALL,NONE,
OUTRES,RSOL,last
OUTRES,NSOL,last
OUTRES,ESOL,last,conc-tank
OUTRES,strs,last,Primary-tank
OUTRES,ESOL,last,J_bolts
OUTRES,Epel,last,liner
outres,esol,last,wall-int-gap
outres,esol,last,conc-excav-wall-gap
outres,esol,last,conc-excav-dome-gap
outres,strs,last,excav-soil
outres,strs,last,bottom-soil
outres,esol,last,bolt-friction
outres,esol,last,waste-surf
outres,strs,last,insul-conc
outres,esol,last,primary-int-gap
outres,esol,last,conc-liner-gap
outres,esol,last,far-soil-contact
outres,esol,last,soil-contact-foot-elem

alphad,alpha
NSUBST,20,200,5,ON
TIME,100
TIMINT,off
acel,0.05*g,0,g
SOLVE
SAVE
TIMINT,on
ITIM=1
DS=TIM
NSUBST,1,20,1,ON

!ddele,master_node,ux
!ddele,master_node,uz

esel,s,type,,61,63,2
mpchg,64,all

esel,s,type,,91,93,2
mpchg,92,all

allsel

*DO,ITIM,1,NTIM,1

TIM=DT*ITIM

TIME,TIM+100

F,master_node,FX,A_1_X(itim)*mass*g
F,master_node,Fz,(A_1_Z(itim)+1)*(mass+ma
ssm_z)*g

SOLVE
SAVE
*ENDDO
FINISH
/out
```

Mu=0.4

Bolts-Friction.txt

```
pi=acos(-1)                    ! Define PI

!ET,4,BEAM44           ! Rigid Links
!KEYOPT,4,8,111
et,4,BEAM4
keyopt,4,6,1

et,31,combin14,,1
et,32,combin14,,2
et,33,combin14,,3

et,34,targe170
et,35,conta173
!keyopt,35,2,3
keyopt,35,5,3
keyopt,35,9,1
keyopt,35,11,1
!keyopt,35,12,4
r,701,0,0,.025
r,702,0,0,.025
r,703,0,0,.025
r,704,0,0,.025
r,705,0,0,.025
r,706,0,0,.025
r,707,0,0,.025
r,708,0,0,.025
r,709,0,0,.025
r,710,0,0,.025
r,711,0,0,.025

BX=33333/20
BY=33333/20
BZ=22777/10
mp,mu,700,0.4

/COM - Create Rigid Links for J-Bolts
nj_bolt=11

mp,ex,401,4176000
mp,nuxy,401,0.30
mp,dens,401,0
r,401,1,10,10,2.5,2.5
rmore,,1e-3
r,402,1,10,10,2.5,2.5
rmore,,1e-3
r,403,1,10,10,2.5,2.5
rmore,,1e-3
r,404,1,10,10,2.5,2.5
rmore,,1e-3
r,405,1,10,10,2.5,2.5
rmore,,1e-3
r,406,1,10,10,2.5,2.5
rmore,,1e-3
r,407,1,10,10,2.5,2.5
rmore,,1e-3
r,408,1,10,10,2.5,2.5
rmore,,1e-3
r,409,1,10,10,2.5,2.5
rmore,,1e-3
r,410,1,10,10,2.5,2.5
rmore,,1e-3
r,411,1,10,10,2.5,2.5
rmore,,1e-3

r,421,1/2,10,10,2.5,2.5
rmore,,1e-3
r,422,1/2,10,10,2.5,2.5
rmore,,1e-3
r,423,1/2,10,10,2.5,2.5
rmore,,1e-3
r,424,1/2,10,10,2.5,2.5
rmore,,1e-3
r,425,1/2,10,10,2.5,2.5
rmore,,1e-3
r,426,1/2,10,10,2.5,2.5
rmore,,1e-3
r,427,1/2,10,10,2.5,2.5
rmore,,1e-3
r,428,1/2,10,10,2.5,2.5
rmore,,1e-3
r,429,1/2,10,10,2.5,2.5
rmore,,1e-3
r,430,1/2,10,10,2.5,2.5
rmore,,1e-3
r,431,1/2,10,10,2.5,2.5
rmore,,1e-3

r,501,1.364*BX
r,502,0.550*BX
r,503,0.887*BX
r,504,1.027*BX
r,505,1.971*BX
r,506,2.407*BX
r,507,3.301*BX
r,508,4.039*BX
r,509,4.369*BX
r,510,5.362*BX
r,511,3.596*BX

r,521,1.364*BY
r,522,0.550*BY
r,523,0.887*BY
r,524,1.027*BY
r,525,1.971*BY
r,526,2.407*BY
r,527,3.301*BY
r,528,4.039*BY
r,529,4.369*BY
r,530,5.362*BY
r,531,3.596*BY

r,541,1.364*BZ
r,542,0.550*BZ
r,543,0.887*BZ
r,544,1.027*BZ
r,545,1.971*BZ
r,546,2.407*BZ
r,547,3.301*BZ
r,548,4.039*BZ
r,549,4.369*BZ
r,550,5.362*BZ
r,551,3.596*BZ

R,601,1.364*BX/2
R,602,0.550*BX/2
R,603,0.887*BX/2
R,604,1.027*BX/2
R,605,1.971*BX/2
R,606,2.407*BX/2
R,607,3.301*BX/2
R,608,4.039*BX/2
R,609,4.369*BX/2
R,610,5.362*BX/2
R,611,3.596*BX/2

R,621,1.364*BY/2
```

```
R,622,0.550*BY/2
R,623,0.887*BY/2
R,624,1.027*BY/2
R,625,1.971*BY/2
R,626,2.407*BY/2
R,627,3.301*BY/2
R,628,4.039*BY/2
R,629,4.369*BY/2
R,630,5.362*BY/2
R,631,3.596*BY/2

R,641,1.364*BZ/2
R,642,0.550*BZ/2
R,643,0.887*BZ/2
R,644,1.027*BZ/2
R,645,1.971*BZ/2
R,646,2.407*BZ/2
R,647,3.301*BZ/2
R,648,4.039*BZ/2
R,649,4.369*BZ/2
R,650,5.362*BZ/2
R,651,3.596*BZ/2

cmsel,s,primary-tank
nsle
nsel,r,loc,z,ptz(1),ptz(11)
cm,bolt-primary-n,node
nsel,none
n,,0,0,ptz(1)
*do,i,2,nj_bolt
*do,j,0,180/arcsize
angley=-j*arcsize
n,,ptx(i),angley,ptz(i)
*enddo
*enddo
cm,bolt-node,node


/COM - Create link at top center of tanks
type,4
mat,401
real,401

nsel,s,loc,x,0                        !
Select nodes on model origin
nsel,r,loc,z,ptz(1),ctz(1)            !
Reselect nodes on concrete and primary
tanks
!nsel,u,node,,1
cmsel,u,bolt-primary-n
eintf,100                             !
Place link at dome center

csys,1
/COM - Create links for J-Bolts
*do,i,2,nj_bolt
        ! Cycle by radius
REAL,400+i
*do,j,1,180/arcsize-1                 !
Cycle by model slice
angley=-j*arcsize                     !
Define angle for node selection
nsel,s,loc,x,ctx(i),ptx(i)            !
Select nodes at radius
nsel,r,loc,y,angley                   !
Reselect nodes at angle "anlgey"
cmsel,u,bolt-primary-n
cmsel,u,waste-n
eintf,100                             !
Create rigid link
*enddo
real,420+i
nsel,s,loc,x,ctx(i),ptx(i)            !
Select nodes at radius
nsel,r,loc,y,0                        !
Reselect nodes at angle 0
cmsel,u,bolt-primary-n
cmsel,u,waste-n
eintf,100                             !
Create rigid link
nsel,s,loc,x,ctx(i),ptx(i)            !
Select nodes at radius
nsel,r,loc,y,180                      !
Reselect nodes at angle 180
cmsel,u,bolt-primary-n
cmsel,u,waste-n
eintf,100                             !
Create rigid link

*enddo

esel,s,type,,4
cm,j_bolts,elem
        ! Create component for J-Bolt
rigid links
allsel


/COM - Create link at top center of tanks
nsel,R,loc,x,0                        !
Select nodes on model origin
nsel,r,loc,z,ptz(1),ptz(1)            !
Reselect nodes on concrete and primary
tanks
TYPE,31
REAL,501
eintf                          ! Place
link at dome center
TYPE,32
REAL,521
eintf                          ! Place
link at dome center
TYPE,33
REAL,541
eintf                          ! Place
link at dome center

csys,1
/COM - Create links for J-Bolts
*do,j,0,2
type,31+j
*do,i,2,nj_bolt
        ! Cycle by radius
REAL,500+20*j+i
*do,k,1,180/arcsize-1                 !
Cycle by model slice
angley=-k*arcsize                     !
Define angle for node selection
nsel,s,loc,x,ptx(i),ptx(i)            !
Select nodes at radius
nsel,r,loc,y,angley                   !
Reselect nodes at angle "anlgey"
cmsel,u,waste-n
eintf                          ! Create
rigid link
*enddo
real,600+j*20+i
nsel,s,loc,x,ptx(i),ptx(i)            !
Select nodes at radius
nsel,r,loc,y,0                        !
Reselect nodes at angle 0
```

```
cmsel,u,waste-n
eintf                          ! Create
rigid link
nsel,s,loc,x,ptx(i),ptx(i)             !
Select nodes at radius
nsel,r,loc,y,180                       !
Reselect nodes at angle 180
cmsel,u,waste-n
eintf                          ! Create
rigid link

*enddo
*enddo

esel,s,type,,31,33
cm,bolt-springs,elem

*do,i,2,10
cmsel,s,conc-tank
nsle
nsel,r,loc,x,ctx(i),ctx(i+1)
nsel,r,loc,z,ctz(i),ctz(i+1)
esln,r
real,700+i
type,34
esurf,,bottom
cmsel,s,primary-tank
nsle
nsel,r,loc,x,ptx(i),ptx(i+1)
nsel,r,loc,z,ptz(i),ptz(i+1)
esln,r
type,35
real,700+i
mat,700
esurf,,bottom
*enddo
esel,s,type,,35
cm,bolt-friction,elem

!*do,i,3,nj_bolt
!cmsel,s,primary-tank
!cmsel,a,conc-tank
!nsle
!nsel,r,loc,z,ptz(i),ctz(i)
!nsel,r,loc,x,ptx(i),ctx(i)
!type,35
!mat,700
!real,700
!eintf,1,high
!*enddo

*get,KMAXjb,KP,0,num,max       ! Get
maximum keypoint number
*get,LMAXjb,LINE,0,num,max     ! Get
maximum line number
*get,AMAXjb,AREA,0,num,max     ! Get
maximum area number
*get,VMAXjb,volu,0,num,max     ! Get
maximum volume number
```

Run-Tank.txt

```
!/batch
! PNNL DST Seismic Analysis, Gravity
Inputs, Best Est Soil, Best Est Concrete
Properties, AP Primary Tank Geometry,
Dome Friction=0.4
!
fini
/clear
/filname,BES-BEC-Mu-040-L,1
/config,nres,3000              ! Increase
allowable number of results to 3000
/config,nproc,2                          !
Activate 2 processers for solution
/config,fsplit,1024            ! Split
binary file at 4.2GB
/prep7
g=32.2                         ! Gravity
(ft/sec)

DF=40                          ! Factor
for beta (stiffness) damping
ALPHA=0.4                      ! Alpha
damping

/out,tank-out,out
/sys,"X:\07.00 - Quality Assurance\ANSYS
QA\usrcfg.bat" > QA.out
/out,QA,out,,append
/input,tank-coordinates-AY,txt           !
Run file defining tank coordinates
(concrete and primary)
/input,tank-props-BEC-250,txt ! Run file
defining fully cracked concrete
properties (PNNL Concrete Properties)
/input,tank-mesh1,txt          ! Develop
concrete tank
/input,primary-props-AY,txt    ! Run file
defining AP Primary tank properties
/input,primary,txt             ! Develop
Primary tank
/input,insulate,txt            ! Develop
insulating concrete model
/input,liner,txt               ! Develop
Liner model
/input,waste-solid-AY,txt      ! Develop
waste model
/input,bolts-friction,txt      ! Develop
J-Bolt model
/input,near-soil-1,txt         ! Develop
excavated soil model

/input,far-soil,txt            ! Develop
Far-Field soil model
/input,interface1,txt          ! Develop
Soil and Concrete Interfaces
/input,interface-gap1,txt      ! Develop
Primary Tank Interfaces
/input,slave,txt               ! Develop
slaved boundary conditions
/input,boundary,txt            ! Place
base and symmetry boundary conditions
/input,outer-spar,txt          ! Connect
soil model to symmetry plane
/input,live_load,txt           ! Apply
live load over a 10ft radius over dome
center
/input,fix-soil,txt
/out
ALLSEL

/out,Tank-th,out

save
```

```
/input,solve-Gravity-BES,txt         !
Run solution Phase
/input,contact-AY,txt         ! Extract
Contact data
/input,all-forces,txt         ! Extract
component forces/strains
/out
!/exit
```

Solve-Gravity-BES.txt

```
/prep7
massm_z=148414.59
d,master_node,all
allsel

cmsel,s,excav-soil
nsle
csys,0
nsel,r,loc,x,-ctx(6)-1,ctx(6)+1
nsel,r,loc,y,0,-ctx(6)-1
esln,r,1
mpchg,810,all

cmsel,s,excav-soil
nsle
csys,1
nsel,r,loc,x,ctx(11)-1,ctx(13)+1
nsel,r,loc,z,soilz(1),soilz(3)-1
esln,r,1
mpchg,810,all

*do,i,801,808
esel,s,mat,,i
mpchg,i+10,all
*enddo
allsel

/out,BEC-BES-Gravity-Dome-F-040-L,out
/solu
antype,trans
TRNOPT,FULL
lumpm,OFF
!nlgeom,on
NROPT,auto
NTIM=10 !NUMBER OF TIME STEPS
DT=0.01
TIM=1e-06
autots,on
KBC,on
TIMINT,ON,STRU
solcontrol,ON,off,,
ncnv,0,200
LNSRCH,OFF
PRED,on,,on

/COM - Time File

/COM - Dimension Horizontal Input
*DIM,A_1_x,,2048
*DIM,A_1_Z,,2048

*VREAD,A_1_x(1),th-266-Mean-geo,txt
(8(F9.6))
*VREAD,A_1_Z(1),th-266-Mean-geo-v,txt
(8(F9.6))

/Title,Load Case: BES-BEC, Gravity, Dome
Friction =0.40, 0.05g Lateral Accel
OUTPR,all,NONE,
OUTRES, ALL,NONE,
OUTRES,RSOL,last
OUTRES,NSOL,last
OUTRES,ESOL,last,conc-tank
OUTRES,strs,last,Primary-tank
OUTRES,ESOL,last,J_bolts
OUTRES,Epel,last,liner
outres,esol,last,wall-int-gap
outres,esol,last,conc-excav-wall-gap
outres,esol,last,conc-excav-dome-gap
outres,strs,last,excav-soil
outres,strs,last,bottom-soil
outres,esol,last,bolt-friction
outres,esol,last,waste-surf
outres,strs,last,insul-conc
outres,esol,last,primary-int-gap
outres,esol,last,conc-liner-gap
outres,esol,last,far-soil-contact
outres,esol,last,soil-contact-foot-elem

alphad,alpha
NSUBST,20,200,5,ON
TIME,100
TIMINT,off
acel,0.05*g,0,g
SOLVE
SAVE
TIMINT,on
ITIM=1
DS=TIM
NSUBST,1,20,1,ON

!ddele,master_node,ux
!ddele,master_node,uz

esel,s,type,,61,63,2
mpchg,64,all

esel,s,type,,91,93,2
mpchg,92,all

allsel

*DO,ITIM,1,NTIM,1

TIM=DT*ITIM

TIME,TIM+100

F,master_node,FX,A_1_X(itim)*mass*g
F,master_node,Fz,(A_1_Z(itim)+1)*(mass+ma
ssm_z)*g

SOLVE
SAVE
*ENDDO
FINISH
/out
```

FULL TRANSIENT ANSYS FILES

Run-Tank.txt

```
/batch
! PNNL DST Seismic Analysis, Horizontal
and Vertical Seismic Inputs, Best
Estimate Soil, Best Estimate Concrete
Properties, AP Primary Tank Geometry
!
fini
/clear
/filname,BES-BEC-No-Dome-Friction,1
/config,nres,3000             ! Increase
allowable number of results to 3000
/config,nproc,2                        !
Activate 2 processers for solution
/config,fsplit,1024           ! Split
binary file at 4.2GB
/prep7
g=32.2                        ! Gravity
(ft/sec)

DF=40                         ! Factor
for beta (stiffness) damping
ALPHA=0.4                     ! Alpha
damping

/out,tank-out,out
/sys,"X:\07.00 - Quality Assurance\ANSYS
QA\usrcfg.bat" > QA.out
/out,QA,out,,append
/input,tank-coordinates-AY,txt        !
Run file defining tank coordinates
(concrete and primary)
/input,tank-props-BEC-250,txt ! Run file
defining fully cracked concrete
properties (PNNL Concrete Properties)
/input,tank-mesh1,txt         ! Develop
concrete tank
/input,primary-props-AY,txt   ! Run file
defining AP Primary tank properties
/input,primary,txt            ! Develop
Primary tank
/input,insulate,txt           ! Develop
insulating concrete model
/input,liner,txt              ! Develop
Liner model
/input,waste-solid-AY,txt     ! Develop
waste model
/input,bolts-friction,txt     ! Develop
J-Bolt model
/input,near-soil-1,txt        ! Develop
excavated soil model

/input,far-soil,txt           ! Develop
Far-Field soil model
/input,interface1,txt         ! Develop
Soil and Concrete Interfaces
/input,interface-gap1,txt     ! Develop
Primary Tank Interfaces
/input,slave,txt              ! Develop
slaved boundary conditions
/input,boundary,txt           ! Place
base and symmetry boundary conditions
/input,outer-spar,txt         ! Connect
soil model to symmetry plane
/input,live_load,txt          ! Apply
live load over a 10ft radius over dome
center
/input,fix-soil,txt
/out
ALLSEL

/out,Tank-th,out

save



/input,solve-TH-BES,txt               !
Run solution Phase
/input,contact-AY,txt         ! Extract
Contact data
/input,all-forces,txt         ! Extract
component forces/strains
/input,spectra-all,txt        ! Extract
Response Spectra
/out
/exit
```

Solve-TH-BES.txt

```
/prep7
massm_z=148414.59
d,master_node,all
allsel

cmsel,s,excav-soil
nsle
csys,0
nsel,r,loc,x,-ctx(6)-1,ctx(6)+1
nsel,r,loc,y,0,-ctx(6)-1
esln,r,1
mpchg,810,all

cmsel,s,excav-soil
nsle
csys,1
nsel,r,loc,x,ctx(11)-1,ctx(13)+1
nsel,r,loc,z,soilz(1),soilz(3)-1
esln,r,1
mpchg,810,all

*do,i,801,808
esel,s,mat,,i
mpchg,i+10,all
*enddo
allsel

/out,AY-BEC-BES-No-Dome-Friction,out
/solu
antype,trans
TRNOPT,FULL
lumpm,OFF
!nlgeom,on
NROPT,auto
NTIM=2048        !NUMBER OF TIME STEPS
DT=0.01
TIM=1e-06
autots,on
KBC,on
TIMINT,ON,STRU
solcontrol,ON,off,,
ncnv,0,200
LNSRCH,OFF
```

```
PRED,on,,on

/COM - Time File

/COM - Dimension Horizontal Input
*DIM,A_1_x,,2048
*DIM,A_1_Z,,2048

*VREAD,A_1_x(1),th-266-Mean-geo,txt
(8(F9.6))
*VREAD,A_1_Z(1),th-266-Mean-geo-v,txt
(8(F9.6))

/Title,Load Case: BES-BEC, Full Non-
linear, Dome Contact Friction = 0.0
OUTPR,all,NONE,
OUTRES, ALL,NONE,
OUTRES,RSOL,last
OUTRES,NSOL,last
OUTRES,ESOL,last,conc-tank
OUTRES,strs,last,Primary-tank
OUTRES,ESOL,last,J_bolts
OUTRES,Epel,last,liner
outres,esol,last,wall-int-gap
outres,esol,last,conc-excav-wall-gap
outres,esol,last,conc-excav-dome-gap
outres,strs,last,excav-soil
outres,strs,last,bottom-soil
outres,esol,last,bolt-friction
outres,esol,last,waste-surf
outres,strs,last,insul-conc
outres,esol,last,primary-int-gap
outres,esol,last,conc-liner-gap
outres,esol,last,far-soil-contact
outres,esol,last,soil-contact-foot-elem

alphad,alpha
NSUBST,20,200,5,ON
TIME,100
TIMINT,off
acel,0,0,g
SOLVE
SAVE
TIMINT,on
ITIM=1
DS=TIM
NSUBST,1,20,1,ON

ddele,master_node,ux
ddele,master_node,uz

esel,s,type,,61,63,2
mpchg,64,all

esel,s,type,,91,93,2
mpchg,92,all

allsel

*DO,ITIM,1,NTIM,1

TIM=DT*ITIM

TIME,TIM+100

F,master_node,FX,A_1_X(itim)*mass*g
F,master_node,Fz,(A_1_Z(itim)+1)*(mass+ma
ssm_z)*g

SOLVE
SAVE
*ENDDO
FINISH
/out
```

GRAVITY ONLY

Run-Tank.txt

```
/batch
! PNNL DST Seismic Analysis, Horizontal
and Vertical Seismic Inputs, Best
Estimate Soil, Best Estimate Concrete
Properties, AP Primary Tank Geometry
!
fini
/clear
/filname,BES-BEC-No-Dome-Friction-
Gravity,1
/config,nres,3000             ! Increase
allowable number of results to 3000
/config,nproc,2                       !
Activate 2 processers for solution
/config,fsplit,1024           ! Split
binary file at 4.2GB
/prep7
g=32.2                        ! Gravity
(ft/sec)

DF=40                         ! Factor
for beta (stiffness) damping
ALPHA=0.4                     ! Alpha
damping

/out,tank-out,out
/sys,"X:\07.00 - Quality Assurance\ANSYS
QA\usrcfg.bat" > QA.out
/out,QA,out,,append
/input,tank-coordinates-AY,txt        !
Run file defining tank coordinates
(concrete and primary)
/input,tank-props-BEC-250,txt ! Run file
defining fully cracked concrete
properties (PNNL Concrete Properties)
/input,tank-mesh1,txt         ! Develop
concrete tank
/input,primary-props-AY,txt   ! Run file
defining AP Primary tank properties
/input,primary,txt            ! Develop
Primary tank
/input,insulate,txt           ! Develop
insulating concrete model
/input,liner,txt              ! Develop
Liner model
/input,waste-solid-AY,txt     ! Develop
waste model
/input,bolts-friction,txt     ! Develop
J-Bolt model
/input,near-soil-1,txt        ! Develop
excavated soil model

/input,far-soil,txt           ! Develop
Far-Field soil model
/input,interface1,txt         ! Develop
Soil and Concrete Interfaces
/input,interface-gap1,txt     ! Develop
Primary Tank Interfaces
/input,slave,txt              ! Develop
slaved boundary conditions
/input,boundary,txt           ! Place
base and symmetry boundary conditions
/input,outer-spar,txt         ! Connect
soil model to symmetry plane
/input,live_load,txt          ! Apply
live load over a 10ft radius over dome
center
/input,fix-soil,txt
/out
ALLSEL

/out,Tank-th,out

save



/input,solve-Gravity-BES,txt          !
Run solution Phase
/input,contact-AY,txt         ! Extract
Contact data
/input,all-forces,txt         ! Extract
component forces/strains
/input,spectra-all,txt        ! Extract
Response Spectra
/out
/exit
```

Solve-Gravity-BES.txt

```
/prep7
massm_z=148414.59
d,master_node,all
allsel

cmsel,s,excav-soil
nsle
csys,0
nsel,r,loc,x,-ctx(6)-1,ctx(6)+1
nsel,r,loc,y,0,-ctx(6)-1
esln,r,1
mpchg,810,all

cmsel,s,excav-soil
nsle
csys,1
nsel,r,loc,x,ctx(11)-1,ctx(13)+1
nsel,r,loc,z,soilz(1),soilz(3)-1
esln,r,1
mpchg,810,all

*do,i,801,808
esel,s,mat,,i
mpchg,i+10,all
*enddo
allsel

/out,BEC-BES-Gravity-Dome-F-000-L,out
/solu
antype,trans
TRNOPT,FULL
lumpm,OFF
!nlgeom,on
NROPT,auto
NTIM=10 !NUMBER OF TIME STEPS
DT=0.01
TIM=1e-06
autots,on
KBC,on
TIMINT,ON,STRU
solcontrol,ON,off,,
ncnv,0,200
LNSRCH,OFF
```

```
PRED,on,,on

/COM - Time File

/COM - Dimension Horizontal Input
*DIM,A_1_x,,2048
*DIM,A_1_Z,,2048

*VREAD,A_1_x(1),th-266-Mean-geo,txt
(8(F9.6))
*VREAD,A_1_Z(1),th-266-Mean-geo-v,txt
(8(F9.6))

/Title,Load Case: BES-BEC, Gravity, Dome
Friction =0.00
OUTPR,all,NONE,
OUTRES, ALL,NONE,
OUTRES,RSOL,last
OUTRES,NSOL,last
OUTRES,ESOL,last,conc-tank
OUTRES,strs,last,Primary-tank
OUTRES,ESOL,last,J_bolts
OUTRES,Epel,last,liner
outres,esol,last,wall-int-gap
outres,esol,last,conc-excav-wall-gap
outres,esol,last,conc-excav-dome-gap
outres,strs,last,excav-soil
outres,strs,last,bottom-soil
outres,esol,last,bolt-friction
outres,esol,last,waste-surf
outres,strs,last,insul-conc
outres,esol,last,primary-int-gap
outres,esol,last,conc-liner-gap
outres,esol,last,far-soil-contact
outres,esol,last,soil-contact-foot-elem

alphad,alpha
NSUBST,20,200,5,ON
TIME,100
TIMINT,off
acel,0,0,g
SOLVE
SAVE
TIMINT,on
ITIM=1
DS=TIM
NSUBST,1,20,1,ON

!ddele,master_node,ux
!ddele,master_node,uz

esel,s,type,,61,63,2
mpchg,64,all

esel,s,type,,91,93,2
mpchg,92,all

allsel

*DO,ITIM,1,NTIM,1

TIM=DT*ITIM

TIME,TIM+100

F,master_node,FX,A_1_X(itim)*mass*g
F,master_node,Fz,(A_1_Z(itim)+1)*(mass+ma
ssm_z)*g

SOLVE
SAVE

*ENDDO
FINISH
/out
```

Appendix B

Results for Static Load Study

List of Tables

Table 1 J-Bolt Forces, 0.05g Lateral Load, μ=0.0

AY Primary Tank, Best Estimate Soil, Mu=0.0, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, 0.05g Lateral Acceleration

ANSYS MAXIMUMS BY RADIUS

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included		Average Bolts per Element	Min Axial Force (kip) BES-BEC Mu=0.0-L	Max Axial Force (kip) BES-BEC Mu=0.0-L	Shear Force1 (kip) BES-BEC Mu=0.0-L	Maximum Shear Force1 Model Angle	Shear Force2 (kip) BES-BEC Mu=0.0-L	Maximum Shear Force2 Model Angle	Total Shear (kip) BES-BEC Mu=0.0-L
		min	max								
Radius 2	44.72	22.36	67.29	0.55	-0.016	-0.012	0.083	99	0.198	0	0.198
Radius 3	89.87	67.29	104.93	0.89	-0.020	-0.014	0.085	99	0.081	0	0.086
Radius 4	120.00	104.93	135.98	1.03	0.001	0.003	0.083	90	0.097	180	0.097
Radius 5	151.97	135.98	181.01	1.97	-0.013	-0.002	0.084	81	0.217	180	0.217
Radius 6	210.05	181.01	223.79	2.41	0.010	0.014	0.102	72	0.495	180	0.495
Radius 7	237.53	223.79	270.98	3.30	0.022	0.057	0.119	72	0.615	180	0.615
Radius 8	304.43	270.98	318.74	4.04	0.041	0.047	0.185	90	0.879	180	0.879
Radius 9	333.05	318.74	361.64	4.37	0.042	0.154	0.232	90	0.967	180	0.967
Radius 10	390.22	361.64	406.24	5.36	0.010	0.129	0.355	72	1.149	180	1.149
Radius 11	422.26	406.24	431.63	3.60	-0.338	0.794	0.542	63	2.036	180	2.036

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included		Average Bolts per Element	Bolt Angle (Rad)	Shear Stiffness (kip/ft)	Axial Stiffness (kip/ft)	Shear Displacement BES-BEC-Mu=0.0-L	Axial Min Displacement BES-BEC-Mu=0.0-L	Axial Max Displacement BES-BEC-Mu=0.0-L
		min	max							
Radius 2	44.72	22.36	67.29	0.55	0.0351	1667	2222	0.00143	-0.00009	-0.00006
Radius 3	89.87	67.29	104.93	0.89	0.0715	1670	2219	0.00062	-0.00011	-0.00008
Radius 4	120.00	104.93	135.98	1.03	0.0968	1673	2215	0.00070	0.00001	0.00002
Radius 5	151.97	135.98	181.01	1.97	0.1252	1677	2207	0.00155	-0.00007	-0.00001
Radius 6	210.05	181.01	223.79	2.41	0.1825	1688	2192	0.00352	0.00005	0.00008
Radius 7	237.53	223.79	270.98	3.30	0.2136	1696	2172	0.00435	0.00012	0.00031
Radius 8	304.43	270.98	318.74	4.04	0.3076	1725	2132	0.00611	0.00023	0.00027
Radius 9	333.05	318.74	361.64	4.37	0.3613	1746	2086	0.00665	0.00024	0.00089
Radius 10	390.22	361.64	406.24	5.36	0.5235	1821	2006	0.00757	0.00006	0.00077
Radius 11	422.26	406.24	431.63	3.60	0.6938	1913	1933	0.01277	-0.00210	0.00493

Table 2 J-Bolt Forces, 0.05g Lateral Load, μ=0.1

AY Primary Tank, Best Estimate Soil, Mu=0.1-L, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, 0.05g Lateral Acceleration

ANSYS MAXIMUMS BY RADIUS

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included		Average Bolts per Element	Min Axial Force (kip) BES-BEC Mu=0.1-L	Max Axial Force (kip) BES-BEC Mu=0.1-L	Shear Force1 (kip) BES-BEC Mu=0.1-L	Maximum Shear Force1 Model Angle	Shear Force2 (kip) BES-BEC Mu=0.1-L	Maximum Shear Force2 Model Angle	Total Shear (kip) BES-BEC Mu=0.1-L
		min	*max*								
Radius 2	44.72	*22.36*	*67.29*	0.55	-0.016	-0.012	0.081	99	0.203	0	0.203
Radius 3	89.87	*67.29*	*104.93*	0.89	-0.021	-0.015	0.082	99	0.091	0	0.092
Radius 4	120.00	*104.93*	*135.98*	1.03	0.001	0.003	0.080	90	0.083	180	0.084
Radius 5	151.97	*135.98*	*181.01*	1.97	-0.014	-0.003	0.081	81	0.200	180	0.200
Radius 6	210.05	*181.01*	*223.79*	2.41	0.009	0.013	0.099	72	0.476	180	0.476
Radius 7	237.53	*223.79*	*270.98*	3.30	0.020	0.054	0.115	72	0.595	180	0.595
Radius 8	304.43	*270.98*	*318.74*	4.04	0.038	0.045	0.181	90	0.859	180	0.859
Radius 9	333.05	*318.74*	*361.64*	4.37	0.040	0.151	0.228	90	0.948	180	0.948
Radius 10	390.22	*361.64*	*406.24*	5.36	0.010	0.124	0.350	72	1.132	180	1.132
Radius 11	422.26	*406.24*	*431.63*	3.60	-0.335	0.795	0.537	63	2.019	180	2.019

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included		Average Bolts per Element	Bolt Angle (Rad)	Shear Stiffness (kip/ft)	Axial Stiffness (kip/ft)	Shear Displacement BES-BEC-Mu=0.1-L	Axial Min Displacement BES-BEC-Mu=0.1-L	Axial Max Displacement BES-BEC-Mu=0.1-L
		min	*max*							
Radius 2	44.72	*22.36*	*67.29*	0.55	0.0351	1667	2222	0.00146	-0.00009	-0.00007
Radius 3	89.87	*67.29*	*104.93*	0.89	0.0715	1670	2219	0.00066	-0.00011	-0.00008
Radius 4	120.00	*104.93*	*135.98*	1.03	0.0968	1673	2215	0.00060	0.00000	0.00001
Radius 5	151.97	*135.98*	*181.01*	1.97	0.1252	1677	2207	0.00143	-0.00007	-0.00002
Radius 6	210.05	*181.01*	*223.79*	2.41	0.1825	1688	2192	0.00338	0.00005	0.00007
Radius 7	237.53	*223.79*	*270.98*	3.30	0.2136	1696	2172	0.00421	0.00011	0.00030
Radius 8	304.43	*270.98*	*318.74*	4.04	0.3076	1725	2132	0.00598	0.00021	0.00025
Radius 9	333.05	*318.74*	*361.64*	4.37	0.3613	1746	2086	0.00651	0.00023	0.00087
Radius 10	390.22	*361.64*	*406.24*	5.36	0.5235	1821	2006	0.00746	0.00006	0.00074
Radius 11	422.26	*406.24*	*431.63*	3.60	0.6938	1913	1933	0.01266	-0.00208	0.00494

Table 3 J-Bolt Forces, 0.05g Lateral Load, μ=0.2

AY Primary Tank, Best Estimate Soil, Mu=0.2-L, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, 0.05g Lateral Acceleration

ANSYS MAXIMUMS BY RADIUS

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included min	Radius of J-Bolts Included max	Average Bolts per Element	Min Axial Force (kip) BES-BEC Mu=0.2-L	Max Axial Force (kip) BES-BEC Mu=0.2-L	Shear Force1 (kip) BES-BEC Mu=0.2-L	Maximum Shear Force1 Model Angle	Shear Force2 (kip) BES-BEC Mu=0.2-L	Maximum Shear Force2 Model Angle	Total Shear (kip) BES-BEC Mu=0.2-L
Radius 2	44.72	*22.36*	*67.29*	0.55	-0.017	-0.013	0.079	99	0.209	0	0.209
Radius 3	89.87	*67.29*	*104.93*	0.89	-0.021	-0.015	0.080	99	0.101	0	0.102
Radius 4	120.00	*104.93*	*135.98*	1.03	0.000	0.002	0.078	90	0.068	180	0.078
Radius 5	151.97	*135.98*	*181.01*	1.97	-0.015	-0.004	0.078	81	0.183	180	0.183
Radius 6	210.05	*181.01*	*223.79*	2.41	0.008	0.012	0.095	72	0.457	180	0.457
Radius 7	237.53	*223.79*	*270.98*	3.30	0.018	0.052	0.111	72	0.574	180	0.574
Radius 8	304.43	*270.98*	*318.74*	4.04	0.035	0.043	0.177	90	0.839	180	0.839
Radius 9	333.05	*318.74*	*361.64*	4.37	0.038	0.148	0.224	90	0.928	180	0.928
Radius 10	390.22	*361.64*	*406.24*	5.36	0.009	0.120	0.345	72	1.114	180	1.114
Radius 11	422.26	*406.24*	*431.63*	3.60	-0.332	0.796	0.532	63	2.003	180	2.003

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included min	Radius of J-Bolts Included max	Average Bolts per Element	Bolt Angle (Rad)	Shear Stiffness (kip/ft)	Axial Stiffness (kip/ft)	Shear Displacement BES-BEC-Mu=0.2-L	Axial Min Displacement BES-BEC-Mu=0.2-L	Axial Max Displacement BES-BEC-Mu=0.2-L
Radius 2	44.72	*22.36*	*67.29*	0.55	0.0351	1667	2222	0.00150	-0.00009	-0.00007
Radius 3	89.87	*67.29*	*104.93*	0.89	0.0715	1670	2219	0.00073	-0.00011	-0.00008
Radius 4	120.00	*104.93*	*135.98*	1.03	0.0968	1673	2215	0.00056	0.00000	0.00001
Radius 5	151.97	*135.98*	*181.01*	1.97	0.1252	1677	2207	0.00131	-0.00008	-0.00002
Radius 6	210.05	*181.01*	*223.79*	2.41	0.1825	1688	2192	0.00325	0.00004	0.00007
Radius 7	237.53	*223.79*	*270.98*	3.30	0.2136	1696	2172	0.00406	0.00010	0.00029
Radius 8	304.43	*270.98*	*318.74*	4.04	0.3076	1725	2132	0.00583	0.00020	0.00024
Radius 9	333.05	*318.74*	*361.64*	4.37	0.3613	1746	2086	0.00638	0.00022	0.00085
Radius 10	390.22	*361.64*	*406.24*	5.36	0.5235	1821	2006	0.00734	0.00005	0.00072
Radius 11	422.26	*406.24*	*431.63*	3.60	0.6938	1913	1933	0.01256	-0.00206	0.00494

Table 4 J-Bolt Forces, 0.05g Lateral Load, μ=0.3

AY Primary Tank, Best Estimate Soil, Mu=0.3, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, 0.05g Lateral Acceleration

ANSYS MAXIMUMS BY RADIUS

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included min	max	Average Bolts per Element	Min Axial Force (kip) BES-BEC Mu=0.3-L	Max Axial Force (kip) BES-BEC Mu=0.3-L	Shear Force1 (kip) BES-BEC Mu=0.3-L	Maximum Shear Force1 Model Angle	Shear Force2 (kip) BES-BEC Mu=0.3-L	Maximum Shear Force2 Model Angle	Total Shear (kip) BES-BEC Mu=0.3-L
Radius 2	44.72	22.36	67.29	0.55	-0.017	-0.013	0.078	99	0.215	0	0.215
Radius 3	89.87	67.29	104.93	0.89	-0.022	-0.016	0.078	99	0.112	0	0.112
Radius 4	120.00	104.93	135.98	1.03	0.000	0.002	0.076	90	0.075	27	0.082
Radius 5	151.97	135.98	181.01	1.97	-0.016	-0.005	0.075	81	0.166	180	0.166
Radius 6	210.05	181.01	223.79	2.41	0.007	0.011	0.092	72	0.438	180	0.438
Radius 7	237.53	223.79	270.98	3.30	0.016	0.049	0.107	72	0.554	180	0.554
Radius 8	304.43	270.98	318.74	4.04	0.033	0.041	0.173	90	0.819	180	0.819
Radius 9	333.05	318.74	361.64	4.37	0.036	0.145	0.219	90	0.908	180	0.908
Radius 10	390.22	361.64	406.24	5.36	0.009	0.115	0.340	72	1.096	180	1.096
Radius 11	422.26	406.24	431.63	3.60	-0.329	0.797	0.527	63	1.985	180	1.985

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included min	max	Average Bolts per Element	Bolt Angle (Rad)	Shear Stiffness (kip/ft)	Axial Stiffness (kip/ft)	Shear Displacement BES-BEC-Mu=0.3-L	Axial Min Displacement BES-BEC-Mu=0.3-L	Axial Max Displacement BES-BEC-Mu=0.3-L
Radius 2	44.72	22.36	67.29	0.55	0.0351	1667	2222	0.00155	-0.00009	-0.00007
Radius 3	89.87	67.29	104.93	0.89	0.0715	1670	2219	0.00081	-0.00012	-0.00008
Radius 4	120.00	104.93	135.98	1.03	0.0968	1673	2215	0.00059	0.00000	0.00001
Radius 5	151.97	135.98	181.01	1.97	0.1252	1677	2207	0.00119	-0.00009	-0.00003
Radius 6	210.05	181.01	223.79	2.41	0.1825	1688	2192	0.00311	0.00004	0.00006
Radius 7	237.53	223.79	270.98	3.30	0.2136	1696	2172	0.00392	0.00009	0.00027
Radius 8	304.43	270.98	318.74	4.04	0.3076	1725	2132	0.00570	0.00018	0.00023
Radius 9	333.05	318.74	361.64	4.37	0.3613	1746	2086	0.00624	0.00021	0.00083
Radius 10	390.22	361.64	406.24	5.36	0.5235	1821	2006	0.00722	0.00005	0.00069
Radius 11	422.26	406.24	431.63	3.60	0.6938	1913	1933	0.01245	-0.00204	0.00495

Table 5 J-Bolt Forces, 0.05g Lateral Load, μ=0.4

AY Primary Tank, Best Estimate Soil, Mu=0.4, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, 0.05g Lateral Acceleration

ANSYS MAXIMUMS BY RADIUS

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included		Average Bolts per Element	Min Axial Force (kip) BES-BEC Mu=0.4-L	Max Axial Force (kip) BES-BEC Mu=0.4-L	Shear Force1 (kip) BES-BEC Mu=0.4-L	Maximum Shear Force1 Model Angle	Shear Force2 (kip) BES-BEC Mu=0.4-L	Maximum Shear Force2 Model Angle	Total Shear (kip) BES-BEC Mu=0.4-L
		min	*max*								
Radius 2	44.72	*22.36*	*67.29*	0.55	-0.017	-0.013	0.077	99	0.221	0	0.221
Radius 3	89.87	*67.29*	*104.93*	0.89	-0.022	-0.016	0.076	99	0.123	0	0.123
Radius 4	120.00	*104.93*	*135.98*	1.03	0.000	0.001	0.074	90	0.089	27	0.093
Radius 5	151.97	*135.98*	*181.01*	1.97	-0.017	-0.006	0.073	81	0.148	180	0.148
Radius 6	210.05	*181.01*	*223.79*	2.41	0.006	0.010	0.089	72	0.419	180	0.419
Radius 7	237.53	*223.79*	*270.98*	3.30	0.014	0.047	0.103	72	0.534	180	0.534
Radius 8	304.43	*270.98*	*318.74*	4.04	0.030	0.039	0.169	90	0.799	180	0.799
Radius 9	333.05	*318.74*	*361.64*	4.37	0.034	0.142	0.215	90	0.889	180	0.889
Radius 10	390.22	*361.64*	*406.24*	5.36	0.008	0.110	0.335	72	1.079	180	1.079
Radius 11	422.26	*406.24*	*431.63*	3.60	-0.326	0.798	0.522	63	1.969	180	1.969

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included		Average Bolts per Element	Bolt Angle (Rad)	Shear Stiffness (kip/ft)	Axial Stiffness (kip/ft)	Shear Displacement BES-BEC-Mu=0.4-L	Axial Min Displacement BES-BEC-Mu=0.4-L	Axial Max Displacement BES-BEC-Mu=0.4-L
		min	*max*							
Radius 2	44.72	*22.36*	*67.29*	0.55	0.0351	1667	2222	0.00159	-0.00009	-0.00007
Radius 3	89.87	*67.29*	*104.93*	0.89	0.0715	1670	2219	0.00089	-0.00012	-0.00009
Radius 4	120.00	*104.93*	*135.98*	1.03	0.0968	1673	2215	0.00067	0.00000	0.00001
Radius 5	151.97	*135.98*	*181.01*	1.97	0.1252	1677	2207	0.00106	-0.00009	-0.00003
Radius 6	210.05	*181.01*	*223.79*	2.41	0.1825	1688	2192	0.00298	0.00003	0.00005
Radius 7	237.53	*223.79*	*270.98*	3.30	0.2136	1696	2172	0.00378	0.00008	0.00026
Radius 8	304.43	*270.98*	*318.74*	4.04	0.3076	1725	2132	0.00556	0.00017	0.00022
Radius 9	333.05	*318.74*	*361.64*	4.37	0.3613	1746	2086	0.00611	0.00019	0.00082
Radius 10	390.22	*361.64*	*406.24*	5.36	0.5235	1821	2006	0.00711	0.00005	0.00066
Radius 11	422.26	*406.24*	*431.63*	3.60	0.6938	1913	1933	0.01235	-0.00203	0.00495

Table 6 Contact Forces, 0.05g Lateral Load, μ=0.0

Tank AY, 422 Inch Waste Level
SpG = 1.7
Best Estimate Soil
Best Estimate Concrete

Radius	Max Pressure Primary Tank/Concrete Tank Dome AY Mu=0.0-L (PSI)	Min Pressure Primary Tank/Concrete Tank Dome AY Mu=0.0-L (PSI)	Max Gap Lateral Displacement Primary Tank /Concrete Tank Dome Mu=0.0-L (in)	Max Gap Displacement Primary Tank/Concete Tank Dome AY Mu=0.0-L (Inches)	Max Sliding Friction Primary Tank/Concete Tank Dome AY Mu=0.0-L (Inches)
67.727	1.516	1.365	0.001768	0.000000	0.001515
105.668	1.147	1.021	0.002753	0.000000	0.001147
137.069	0.748	0.602	0.002646	0.000000	0.000748
182.849	0.883	0.835	0.003948	0.000000	0.000883
226.563	1.005	0.881	0.002711	-0.000034	0.001005
275.566	0.610	0.521	0.002779	-0.000025	0.000610
325.690	1.417	1.177	0.003749	-0.000149	0.001417
372.305	0.501	0.284	0.003827	-0.000234	0.000501
423.427	1.058	0.000	0.004207	-1.055880	0.001058

Table 7 Contact Forces, 0.05g Lateral Load, μ=0.1

Tank AY, 422 Inch Waste Level
SpG = 1.7
Best Estimate Soil
Best Estimate Concrete

Radius	Max Pressure Primary Tank/Concrete Tank Dome AY Mu=0.1-L (PSI)	Min Pressure Primary Tank/Concrete Tank Dome AY Mu=0.1-L (PSI)	Max Gap Lateral Displacement Primary Tank /Concrete Tank Dome Mu=0.1-L (in)	Max Gap Displacement Primary Tank/Concete Tank Dome AY Mu=0.1-L (Inches)	Max Sliding Friction Primary Tank/Concete Tank Dome AY Mu=0.1-L (Inches)
67.727	1.551	1.397	0.001712	0.000000	0.155000
105.668	1.149	1.028	0.002668	0.000000	0.114931
137.069	0.772	0.624	0.002370	0.000000	0.077222
182.849	0.888	0.843	0.003775	0.000000	0.088819
226.563	0.993	0.892	0.002705	-0.000032	0.099306
275.566	0.608	0.523	0.002594	-0.000021	0.060750
325.690	1.419	1.194	0.003671	-0.000146	0.141944
372.305	0.491	0.286	0.003752	-0.000226	0.049118
423.427	1.064	0.000	0.004169	-1.055880	0.106389

Table 8 Contact Forces, 0.05g Lateral Load, μ=0.2

Tank AY, 422 Inch Waste Level
SpG = 1.7
Best Estimate Soil
Best Estimate Concrete

Radius	Max Pressure Primary Tank/Concrete Tank Dome AY Mu=0.2-L (PSI)	Min Pressure Primary Tank/Concrete Tank Dome AY Mu=0.2-L (PSI)	Max Gap Lateral Displacement Primary Tank /Concrete Tank Dome Mu=0.2-L (in)	Max Gap Displacement Primary Tank/Concete Tank Dome AY Mu=0.2-L (Inches)	Max Sliding Friction Primary Tank/Concete Tank Dome AY Mu=0.2-L (Inches)
67.727	1.587	1.429	0.001652	0.000000	0.317222
105.668	1.152	1.034	0.002580	0.000000	0.230347
137.069	0.797	0.647	0.002358	-0.000001	0.159444
182.849	0.894	0.851	0.003600	0.000000	0.178819
226.563	1.001	0.895	0.002756	-0.000029	0.200139
275.566	0.604	0.524	0.002738	-0.000018	0.120764
325.690	1.421	1.203	0.003668	-0.000143	0.284236
372.305	0.481	0.288	0.003677	-0.000218	0.096181
423.427	1.070	0.000	0.004129	-1.055880	0.214028

Table 9 Contact Forces, 0.05g Lateral Load, μ=0.3

Tank AY, 422 Inch Waste Level
SpG = 1.7
Best Estimate Soil
Best Estimate Concrete

Radius	Max Pressure Primary Tank/Concrete Tank Dome AY Mu=0.3-L (PSI)	Min Pressure Primary Tank/Concrete Tank Dome AY Mu=0.3-L (PSI)	Max Gap Lateral Displacement Primary Tank /Concrete Tank Dome Mu=0.3-L (in)	Max Gap Displacement Primary Tank/Concete Tank Dome AY Mu=0.3-L (Inches)	Max Sliding Friction Primary Tank/Concete Tank Dome AY Mu=0.3-L (Inches)
67.727	1.623	1.463	0.001591	0.000000	0.486806
105.668	1.154	1.040	0.002490	0.000000	0.346250
137.069	0.822	0.669	0.002100	-0.000001	0.246667
182.849	0.900	0.859	0.003467	0.000000	0.269931
226.563	1.016	0.896	0.002801	-0.000027	0.304861
275.566	0.599	0.526	0.002648	-0.000015	0.179861
325.690	1.423	1.213	0.003678	-0.000140	0.426806
372.305	0.470	0.289	0.003600	-0.000210	0.141111
423.427	1.076	0.000	0.004090	-1.055880	0.322986

Table 10 Contact Forces, 0.05g Lateral Load, μ=0.4

Tank AY, 422 Inch Waste Level
SpG = 1.7
Best Estimate Soil
Best Estimate Concrete

Radius	Max Pressure Primary Tank/Concrete Tank Dome AY Mu=0.4-L (PSI)	Min Pressure Primary Tank/Concrete Tank Dome AY Mu=0.4-L (PSI)	Max Gap Lateral Displacement Primary Tank /Concrete Tank Dome Mu=0.4-L (in)	Max Gap Displacement Primary Tank/Concete Tank Dome AY Mu=0.4-L (Inches)	Max Sliding Friction Primary Tank/Concete Tank Dome AY Mu=0.4-L (Inches)
67.727	1.660	1.496	0.001526	0.000000	0.664167
105.668	1.157	1.045	0.002396	0.000000	0.462708
137.069	0.850	0.692	0.001564	-0.000001	0.340000
182.849	0.906	0.867	0.003331	0.000000	0.362222
226.563	1.031	0.885	0.002753	-0.000025	0.412569
275.566	0.598	0.528	0.002544	-0.000011	0.239236
325.690	1.424	1.223	0.003527	-0.000137	0.569375
372.305	0.460	0.278	0.003522	-0.000201	0.184167
423.427	1.083	0.000	0.003415	-1.055880	0.433403

Table 11 Concrete Forces and Moments, 0.05g Lateral Load, μ=0.0

AY Primary Tank, Best Estimate Soil (Geomatrix), Best Estimate Concrete, 422 in. Waste Level at 1.7 SpG, 0.05g Lateral Load, Dome Friction =0.0

ANSYS MAXIMUMS BY PATH

PNNL Section No.	Path (in.)	Gravity Hoop Force (kip/ft) AY-BES-BEC, Mu=0.0	Gravity Meridonal Force (kip/ft) AY-BES-BEC, Mu=0.0	Gravity -In-Plane Shear Force (kip/ft) AY-BES-BEC, Mu=0.0	Gravity Hoop Moment (ft*kip/ft) AY-BES-BEC, Mu=0.0	Gravity Meridonal Moment (ft*kip/ft) AY-BES-BEC, Mu=0.0	Gravity Through-Wall Shear Force (kip/ft) AY-BES-BEC, Mu=0.0
2	**67.727**	-71.060	-75.800	-0.250	-7.951	-4.834	2.051
3	**105.668**	-65.200	-74.040	-0.478	-5.605	-1.986	1.196
4	**137.069**	-59.620	-72.010	-0.690	-3.909	1.232	1.340
6	**182.849**	-53.850	-68.680	-0.881	-2.354	2.168	0.339
8	**226.563**	-49.360	-66.130	-1.027	-1.837	-0.814	-0.795
9	**275.566**	-45.560	-63.910	-1.462	-1.885	-1.426	-0.732
11	**325.690**	-37.650	-62.060	-1.882	-2.309	-4.519	-0.764
13	**372.305**	-29.400	-60.100	-2.382	-4.854	-5.399	-0.448
17	**423.427**	-10.580	-57.930	-2.924	-2.476	-3.695	2.164
20	**468.308**	41.010	-55.450	-3.542	-8.797	15.720	8.429
22	**515.312**	18.230	-57.330	-4.103	4.653	29.150	-3.504
24	**549.725**	2.614	-55.910	-4.048	2.320	12.690	-6.817
26	**585.819**	-12.220	-57.430	-4.206	0.116	0.625	-2.820
30	**636.369**	-24.290	-59.050	-4.420	-0.477	-2.642	0.820
33	**685.619**	-28.980	-60.340	-4.616	-0.101	-0.546	0.343
35	**732.719**	-32.670	-62.110	-4.834	0.050	0.253	-0.063
38	**778.219**	-28.780	-63.930	-5.041	-0.158	-0.865	-0.232
41	**821.369**	-29.290	-66.340	-5.310	-0.051	-0.266	-0.179
43	**874.169**	-17.800	-39.930	-3.495	-0.479	-2.640	-0.243
46	**930.544**	-42.540	-69.910	-5.940	-0.891	-4.849	-0.978
48	**977.629**	-4.536	-11.140	2.021	-3.522	16.920	-9.755
51	**1019.647**	-8.397	-16.450	1.749	-1.663	16.860	9.958
53	**1060.156**	-1.645	-5.581	0.472	0.630	2.716	-2.619
55	**1109.695**	4.455	-3.147	-0.570	0.131	0.327	0.407
57	**1155.770**	1.770	0.621	-0.528	0.020	0.050	-0.090
58	**1211.956**	2.162	1.346	-0.442	0.023	0.061	0.085
59	**1281.707**	1.652	1.357	-0.290	0.018	0.081	-0.092
60	**1330.557**	1.420	1.275	-0.228	-0.005	-0.041	-0.068
61	**1374.857**	0.998	1.723	-0.288	0.011	0.016	0.183
62	**1417.007**	4.063	3.555	-0.317	0.128	0.375	0.124

Note: Meridonal/Hoop Forces and Meridonal/Hoop Moments are Reversed in Highlighted Sections.

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AY-2D-NL-BES-BEC Conc Tank Demand Gravity Mu=0.0-L.xls, FM Max

Table 12 Concrete Forces and Moments, 0.05g Lateral Load, μ=0.4

AY Primary Tank, Best Estimate Soil (Geomatrix), Best Estimate Concrete, 422 in. Waste Level at 1.7 SpG, 0.05g Lateral Load, Dome Friction = 0.4

ANSYS MAXIMUMS BY PATH

PNNL Section No.	Path (in.)	Gravity Hoop Force (kip/ft) AY-BES-BEC, Mu=0.4	Gravity Meridonal Force (kip/ft) AY-BES-BEC, Mu=0.4	Gravity -In-Plane Shear Force (kip/ft) AY-BES-BEC, Mu=0.4	Gravity Hoop Moment (ft*kip/ft) AY-BES-BEC, Mu=0.4	Gravity Meridonal Moment (ft*kip/ft) AY-BES-BEC, Mu=0.4	Gravity Through-Wall Shear Force (kip/ft) AY-BES-BEC, Mu=0.4
2	**67.727**	-70.360	-75.220	-0.251	-7.921	-4.807	2.056
3	**105.668**	-64.610	-73.660	-0.493	-5.581	-1.974	1.192
4	**137.069**	-59.100	-71.660	-0.692	-3.891	1.242	1.349
6	**182.849**	-53.450	-68.470	-0.888	-2.343	2.162	0.346
8	**226.563**	-49.050	-66.020	-1.037	-1.832	-0.832	-0.786
9	**275.566**	-45.320	-63.800	-1.476	-1.881	-1.436	-0.716
11	**325.690**	-37.480	-62.020	-1.901	-2.306	-4.524	-0.755
13	**372.305**	-29.230	-60.070	-2.397	-4.850	-5.409	-0.433
17	**423.427**	-10.550	-57.980	-2.947	-2.477	-3.708	2.173
20	**468.308**	41.020	-55.470	-3.556	-8.800	15.700	8.434
22	**515.312**	18.230	-57.350	-4.110	4.653	29.150	-3.502
24	**549.725**	2.612	-55.920	-4.054	2.320	12.690	-6.817
26	**585.819**	-12.210	-57.450	-4.211	0.116	0.625	-2.820
30	**636.369**	-24.290	-59.060	-4.425	-0.477	-2.643	0.820
33	**685.619**	-28.980	-60.350	-4.621	-0.101	-0.546	0.343
35	**732.719**	-32.670	-62.120	-4.838	0.050	0.253	-0.063
38	**778.219**	-28.780	-63.940	-5.045	-0.158	-0.865	-0.232
41	**821.369**	-29.290	-66.350	-5.314	-0.051	-0.266	-0.179
43	**874.169**	-17.800	-39.930	-3.497	-0.479	-2.640	-0.243
46	**930.544**	-42.530	-69.920	-5.943	-0.891	-4.849	-0.978
48	**977.629**	-4.535	-11.140	2.020	-3.522	16.930	-9.758
51	**1019.647**	-8.393	-16.450	1.749	-1.663	16.870	9.961
53	**1060.156**	-1.643	-5.581	0.472	0.631	2.718	-2.622
55	**1109.695**	4.455	-3.146	-0.571	0.131	0.326	0.407
57	**1155.770**	1.770	0.622	-0.528	0.020	0.050	-0.090
58	**1211.956**	2.162	1.347	-0.441	0.023	0.061	0.086
59	**1281.707**	1.652	1.357	-0.290	0.018	0.081	-0.092
60	**1330.557**	1.420	1.276	-0.228	-0.005	-0.041	-0.068
61	**1374.857**	0.998	1.724	-0.288	0.011	0.016	0.183
62	**1417.007**	4.064	3.556	-0.316	0.128	0.375	0.124

Note: Meridonal/Hoop Forces and Meridonal/Hoop Moments are Reversed in Highlighted Sections.

Table 13 Primary Tank Stresses, Shell Top, 0.05g Lateral Load, μ=0.0

		AY Primary Tank, Best Estimate Soil, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, 05g Lateral Load, Dome Friction = 0.0					
		Shell Top Surface (inside - waste side)					
M&D Starting M&D Element No.	Path (in.)	Hoop Stress (lbs/in^2) Top	Meridional Stress (lbs/in^2) Top	Stress Intensity (lbs/in^2) Top	In-Plane Shear Stress (lbs/in^2) Top	In-Plane Shear Force Stress (lbs/in^2) Top	Thru-Thickness Shear Stress (lbs/in^2) Top
762	**67.33**	-1859.72	0.00	1859.72	7.22	10.93	0.18
782	**105.04**	-1795.14	-3036.81	3037.50	14.50	-27.06	0.03
802	**136.24**	-1763.89	-2078.47	2079.17	14.45	24.85	-0.05
822	**181.71**	-1173.61	-2420.14	2420.14	-22.01	-6.51	0.03
842	**225.10**	-1317.36	-1489.58	1489.58	-22.24	-9.26	-0.14
862	**273.66**	-589.17	-1837.50	1837.50	-40.08	6.84	0.09
882	**323.27**	-663.26	-905.56	908.33	-66.91	-22.03	-0.11
902	**369.20**	526.46	-1300.69	1827.78	-101.39	-8.67	0.47
922	**419.20**	894.44	-262.78	1177.78	-180.42	20.32	0.41
942	**444.11**	1643.06	-1593.75	3143.06	-249.86	81.25	2.99
962	**471.06**	2596.53	893.75	3181.25	-304.10	-15.08	2.46
982	**503.51**	2205.56	-421.74	2336.11	-404.44	38.40	2.74
1002	**527.76**	4553.47	-187.99	4577.78	-337.50	-28.72	-0.92
1022	**554.76**	5948.61	-371.04	5949.31	-147.15	-11.26	0.29
1042	**582.26**	7326.39	-235.90	7326.39	122.29	-14.63	-0.10
1062	**609.26**	8715.28	-429.10	8715.28	211.67	-12.82	0.10
1082	**636.26**	10354.17	-303.13	10354.17	299.58	-11.13	-0.06
1102	**663.26**	12020.83	-361.39	12020.83	378.96	-10.57	0.05
1122	**688.61**	13763.89	-322.01	13770.83	454.79	25.38	-0.06
1142	**711.96**	15187.50	-649.65	15486.11	519.03	-35.30	0.06
1162	**734.96**	15812.50	-185.21	15826.39	654.17	33.01	0.05
1182	**757.91**	15409.72	-1746.53	17138.89	654.17	-38.20	0.12
1202	**782.81**	13812.50	1956.94	13812.50	463.40	-28.33	-0.11
1222	**809.76**	13256.94	-280.63	13437.50	481.18	17.93	-0.08
1242	**836.76**	13951.39	217.85	13958.33	489.10	-21.63	0.14
1262	**863.76**	15437.50	261.39	15493.06	512.92	-5.44	-0.22
1282	**889.76**	13215.28	-4856.25	18076.39	531.46	-17.85	1.00
1302	**906.85**	4859.72	-10520.83	14263.89	485.97	152.01	-3.41
1322	**916.04**	4747.92	7847.22	7902.78	503.19	438.61	-7.08
1342	**934.63**	3523.61	9680.56	9750.00	-877.78	11.19	-136.81
1362	**974.63**	-639.24	-1656.25	1968.06	-380.00	-3.66	46.00
1382	**1040.78**	1329.17	2032.64	2057.64	-358.89	2.24	-28.33
1402	**1110.53**	387.64	-1231.94	1329.17	89.93	-3.17	40.28

Table 14 Primary Tank Stresses, Shell Middle, 0.05g Lateral Load, μ=0.0

		AY Primary Tank, Best Estimate Soil, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, 05g Lateral Load, Dome Friction = 0.0					
		Shell Mid-Plane					
M&D Starting M&D Element No.	Path (in.)	Hoop Stress (lbs/in^2) Mid	Meridional Stress (lbs/in^2) Mid	Stress Intensity (lbs/in^2) Mid	In-Plane Shear Stress (lbs/in^2) Mid	In-Plane Shear Force Stress (lbs/in^2) Mid	Thru-Thickness Shear Stress (lbs/in^2) Mid
762	**67.33**	-2018.75	-1913.19	2018.75	8.03	10.93	0.18
782	**105.04**	-1717.36	-2551.39	2552.08	13.88	-27.06	0.03
802	**136.24**	-1927.78	-2390.28	2390.97	14.28	24.85	-0.05
822	**181.71**	-1150.00	-2122.22	2122.22	-21.24	-6.51	0.03
842	**225.10**	-1513.89	-1874.31	1874.31	-22.04	-9.49	-0.14
862	**273.66**	-580.35	-1584.72	1584.72	-39.69	6.99	0.09
882	**323.27**	-842.36	-1275.69	1276.39	-66.85	-22.51	-0.11
902	**369.20**	611.39	-1002.08	1613.89	-101.32	-8.67	0.47
922	**419.20**	904.17	-653.13	1214.58	-180.97	20.32	0.41
942	**444.11**	1942.36	-443.61	2397.22	-258.54	84.65	2.99
962	**471.06**	2654.86	-392.64	3048.61	-306.18	-15.56	2.46
982	**503.51**	2270.83	-374.17	2279.17	-387.64	38.40	2.74
1002	**527.76**	4671.53	-411.53	4674.31	-332.50	-28.72	-0.92
1022	**554.76**	5972.92	-331.88	5973.61	-147.22	-11.26	0.29
1042	**582.26**	7402.78	-347.29	7402.78	118.47	-14.63	-0.10
1062	**609.26**	8729.17	-363.19	8729.17	209.65	-12.83	0.10
1082	**636.26**	10409.72	-363.13	10409.72	296.67	-11.13	-0.06
1102	**663.26**	12034.72	-358.82	12034.72	377.78	-10.57	0.05
1122	**688.61**	13791.67	-344.65	13798.61	454.79	25.38	-0.06
1142	**711.96**	15326.39	-325.00	15340.28	598.75	-35.30	0.06
1162	**734.96**	15819.44	-303.19	15840.28	598.75	33.01	0.05
1182	**757.91**	15819.44	-267.57	16041.67	646.25	-38.20	0.12
1202	**782.81**	13513.89	-152.22	13576.39	449.38	-28.93	-0.11
1222	**809.76**	13305.56	-145.21	13395.83	470.56	18.57	-0.08
1242	**836.76**	13868.06	-160.07	14006.94	489.17	-22.09	0.14
1262	**863.76**	15416.67	-181.46	15597.22	511.04	-5.44	-0.22
1282	**889.76**	14625.00	-231.32	14854.17	530.07	-18.38	1.00
1302	**906.85**	7090.28	-148.96	7333.33	462.85	152.01	-3.41
1322	**916.04**	2380.56	73.68	2690.97	471.88	443.68	-7.08
1342	**934.63**	1206.94	340.69	1248.61	-393.61	11.20	-138.47
1362	**974.63**	1166.67	692.50	1195.83	-497.71	-3.70	46.53
1382	**1040.78**	970.83	607.64	972.22	-287.22	2.25	-28.59
1402	**1110.53**	839.58	605.14	841.67	-172.43	-3.18	40.56

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AY-2D-NL-BES-BEC Pri Tank Stress Gravity Mu=0.0-L.xls, Stress Max

Table 15 Primary Tank Stresses, Shell Bottom, 0.05g Lateral Load, μ=0.0

		AY Primary Tank, Best Estimate Soil, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, 05g Lateral Load, Dome Friction = 0.0					
		Shell Bottom Surface (outside - away from waste)					
M&D Starting M&D Element No.	Path (in.)	Hoop Stress (lbs/in^2) Bot	Meridional Stress (lbs/in^2) Bot	Stress Intensity (lbs/in^2) Bot	In-Plane Shear Stress (lbs/in^2) Bot	In-Plane Shear Force Stress (lbs/in^2) Bot	Thru-Thickness Shear Stress (lbs/in^2) Bot
762	**67.33**	-2181.94	-2377.08	2377.08	10.60	10.93	0.18
782	**105.04**	-1684.03	-2290.28	2290.97	13.73	-27.06	0.03
802	**136.24**	-2090.97	-2887.50	2888.19	14.24	24.85	-0.05
822	**181.71**	-1124.31	-1883.33	1883.33	-20.47	-6.51	0.03
842	**225.10**	-1710.42	-2510.42	2510.42	-22.03	-9.49	-0.14
862	**273.66**	-566.11	-1335.42	1337.50	-39.31	6.99	0.09
882	**323.27**	-1022.22	-1884.03	1884.03	-66.78	-22.51	-0.11
902	**369.20**	696.53	-704.17	1400.69	-101.25	-8.67	0.47
922	**419.20**	919.44	-1260.42	1406.25	-181.53	20.32	0.41
942	**444.11**	2242.36	1269.44	2250.00	-267.29	84.65	2.99
962	**471.06**	2712.50	-443.82	2916.67	-308.26	-15.56	2.46
982	**503.51**	2328.47	414.44	2339.58	-370.90	38.40	2.74
1002	**527.76**	4737.50	-756.94	4738.89	-327.43	-28.72	-0.92
1022	**554.76**	5933.33	-292.99	5936.11	-147.22	-11.26	0.29
1042	**582.26**	7430.56	-458.68	7430.56	114.72	-14.63	-0.10
1062	**609.26**	8694.44	-297.36	8694.44	207.57	-12.83	0.10
1082	**636.26**	10430.56	-423.19	10430.56	288.89	-11.13	-0.06
1102	**663.26**	12006.94	-356.32	12006.94	376.67	-10.57	0.05
1122	**688.61**	13791.67	-430.69	13798.61	454.72	25.38	-0.06
1142	**711.96**	15430.56	399.17	15430.56	586.53	-35.30	0.06
1162	**734.96**	15791.67	-421.11	15881.94	586.53	33.01	0.05
1182	**757.91**	16298.61	1394.44	16319.44	638.33	-38.20	0.12
1202	**782.81**	13180.56	-2108.33	14340.28	437.01	-28.93	-0.11
1222	**809.76**	13333.33	76.18	13354.17	461.39	18.57	-0.08
1242	**836.76**	13770.83	-455.21	14229.17	489.38	-22.09	0.14
1262	**863.76**	15381.94	-501.11	15687.50	509.24	-5.15	-0.22
1282	**889.76**	16013.89	4499.31	16013.89	528.61	-18.38	1.00
1302	**906.85**	9750.00	10388.89	10395.83	441.11	152.01	-3.41
1322	**916.04**	-1577.78	-7750.00	7798.61	440.63	443.68	-7.08
1342	**934.63**	-3108.33	-9048.61	9083.33	441.60	11.20	-138.47
1362	**974.63**	1745.14	3038.89	3068.75	-615.83	-3.70	46.53
1382	**1040.78**	612.50	-832.64	1265.97	-215.56	2.25	-28.59
1402	**1110.53**	1291.67	2436.11	2452.78	-264.79	-3.18	40.56

Table 16 Primary Tank Stresses, Shell Top, 0.05g Lateral Load, μ=0.4

		AY Primary Tank, Best Estimate Soil, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, 0.05g Lateral Load, Dome Friction = 0.4					
		Shell Top Surface (inside - waste side)					
M&D Starting M&D Element No.	Path (in.)	Hoop Stress (lbs/in^2) Top	Meridional Stress (lbs/in^2) Top	Stress Intensity (lbs/in^2) Top	In-Plane Shear Stress (lbs/in^2) Top	In-Plane Shear Force Stress (lbs/in^2) Top	Thru-Thickness Shear Stress (lbs/in^2) Top
762	**67.33**	-2007.64	0.00	2007.64	7.88	11.60	0.19
782	**105.04**	-1925.69	-3172.92	3173.61	12.12	-28.72	0.04
802	**136.24**	-1895.83	-2156.94	2157.64	14.97	26.38	-0.05
822	**181.71**	-1246.53	-2497.22	2497.22	-24.29	-6.71	0.03
842	**225.10**	-1413.89	-1499.31	1499.31	-24.98	-9.83	-0.14
862	**273.66**	-628.68	-1870.14	1870.14	-42.83	7.39	0.09
882	**323.27**	-725.00	-879.86	881.25	-70.07	-23.39	-0.11
902	**369.20**	483.47	-1311.11	1794.44	-103.06	7.99	0.47
922	**419.20**	872.22	-248.06	1139.58	-186.04	19.38	0.42
942	**444.11**	1597.22	-1590.97	3096.53	-253.54	85.00	3.01
962	**471.06**	2556.25	918.06	3134.03	-306.94	-15.49	2.48
982	**503.51**	2203.47	-413.26	2323.61	-406.04	37.83	2.76
1002	**527.76**	4603.47	-188.82	4620.83	-339.24	-28.42	-0.92
1022	**554.76**	6012.50	-365.63	6012.50	-148.40	-11.33	0.29
1042	**582.26**	7375.00	-234.93	7375.00	120.69	-14.49	-0.10
1062	**609.26**	8756.94	-424.38	8756.94	210.14	-12.87	0.10
1082	**636.26**	10388.89	-301.18	10388.89	297.99	-11.06	-0.06
1102	**663.26**	12055.56	-357.71	12055.56	377.43	-10.59	0.05
1122	**688.61**	13798.61	-320.00	13805.56	453.33	25.41	-0.06
1142	**711.96**	15222.22	-646.60	15506.94	517.50	-35.32	0.06
1162	**734.96**	15847.22	-182.85	15854.17	652.57	33.03	0.05
1182	**757.91**	15444.44	-1744.44	17138.89	652.57	-38.22	0.12
1202	**782.81**	13847.22	1958.33	13847.22	462.43	-28.91	-0.11
1222	**809.76**	13277.78	-279.24	13451.39	480.28	18.54	-0.08
1242	**836.76**	13965.28	219.79	13972.22	488.26	-22.05	0.14
1262	**863.76**	15451.39	258.82	15513.89	511.94	-5.48	-0.22
1282	**889.76**	13222.22	-4862.50	18083.33	530.49	-18.15	1.00
1302	**906.85**	4859.03	-10576.39	14284.72	485.00	151.94	-3.40
1322	**916.04**	4745.14	7888.89	7937.50	502.15	442.64	-7.07
1342	**934.63**	3519.44	9715.28	9770.83	-875.69	11.18	-138.26
1362	**974.63**	-678.89	-1652.08	1965.28	-379.38	-3.69	46.46
1382	**1040.78**	1328.47	2040.28	2056.25	-358.47	2.25	-28.55
1402	**1110.53**	388.33	-1228.47	1327.78	89.86	-3.18	40.50

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AY-2D-NL-BES-BEC Pri Tank Stress Gravity Mu=0.4-L.xls, Stress Max

Table 17 Primary Tank Stresses, Shell Middle, 0.05g Lateral Load, μ=0.4

		AY Primary Tank, Best Estimate Soil, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, 0.05g Lateral Load, Dome Friction = 0.4					
		Shell Mid-Plane					
M&D Starting M&D Element No.	Path (in.)	Hoop Stress (lbs/in^2) Mid	Meridional Stress (lbs/in^2) Mid	Stress Intensity (lbs/in^2) Mid	In-Plane Shear Stress (lbs/in^2) Mid	In-Plane Shear Force Stress (lbs/in^2) Mid	Thru-Thickness Shear Stress (lbs/in^2) Mid
762	**67.33**	-2172.92	-2032.64	2172.92	8.73	11.60	0.19
782	**105.04**	-1819.44	-2662.50	2662.50	11.45	-28.72	0.04
802	**136.24**	-2067.36	-2497.92	2498.61	14.95	26.38	-0.05
822	**181.71**	-1215.28	-2184.03	2184.03	-23.63	-6.71	0.03
842	**225.10**	-1620.14	-1917.36	1917.36	-25.06	-9.83	-0.14
862	**273.66**	-612.78	-1605.56	1605.56	-42.46	7.39	0.09
882	**323.27**	-911.11	-1281.25	1281.25	-69.93	-23.39	-0.11
902	**369.20**	570.69	-1004.17	1575.00	-103.06	7.99	0.47
922	**419.20**	881.25	-638.40	1179.86	-186.60	19.38	0.42
942	**444.11**	1899.31	-435.83	2345.83	-262.29	85.00	3.01
962	**471.06**	2613.89	-386.60	3002.08	-308.96	-15.49	2.48
982	**503.51**	2260.42	-369.24	2268.75	-389.38	37.83	2.76
1002	**527.76**	4670.83	-406.74	4673.61	-334.24	-28.42	-0.92
1022	**554.76**	5972.22	-328.54	5973.61	-148.40	-11.33	0.29
1042	**582.26**	7402.78	-344.10	7402.78	116.88	-14.49	-0.10
1062	**609.26**	8729.17	-360.14	8729.17	208.06	-12.87	0.10
1082	**636.26**	10409.72	-360.21	10409.72	295.00	-11.06	-0.06
1102	**663.26**	12034.72	-355.97	12034.72	376.25	-10.59	0.05
1122	**688.61**	13791.67	-341.88	13798.61	453.26	25.41	-0.06
1142	**711.96**	15326.39	-322.29	15340.28	597.29	-35.32	0.06
1162	**734.96**	15819.44	-300.56	15840.28	597.29	33.03	0.05
1182	**757.91**	15819.44	-265.14	16041.67	644.65	-38.22	0.12
1202	**782.81**	13513.89	-150.69	13569.44	448.40	-28.91	-0.11
1222	**809.76**	13305.56	-143.68	13395.83	469.58	18.54	-0.08
1242	**836.76**	13868.06	-158.54	14000.00	488.26	-22.05	0.14
1262	**863.76**	15416.67	-179.86	15597.22	510.07	-5.48	-0.22
1282	**889.76**	14611.11	-229.72	14847.22	529.03	-18.15	1.00
1302	**906.85**	7083.33	-147.85	7326.39	461.94	151.94	-3.40
1322	**916.04**	2378.47	74.79	2687.50	470.97	442.64	-7.07
1342	**934.63**	1206.25	341.18	1247.92	-392.92	11.18	-138.26
1362	**974.63**	1166.67	693.19	1195.14	-496.94	-3.69	46.46
1382	**1040.78**	970.83	608.19	972.22	-286.88	2.25	-28.55
1402	**1110.53**	839.58	605.63	841.67	-172.29	-3.18	40.50

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AY-2D-NL-BES-BEC Pri Tank Stress Gravity Mu=0.4-L.xls, Stress Max

Table 18 Primary Tank Stresses, Shell Bottom, 0.05g Lateral Load, μ=0.4

		AY Primary Tank, Best Estimate Soil, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, 0.05g Lateral Load, Dome Friction = 0.4					
		Shell Bottom Surface (outside - away from waste)					
M&D Starting M&D Element No.	Path (in.)	Hoop Stress (lbs/in^2) Bot	Meridional Stress (lbs/in^2) Bot	Stress Intensity (lbs/in^2) Bot	In-Plane Shear Stress (lbs/in^2) Bot	In-Plane Shear Force Stress (lbs/in^2) Bot	Thru-Thickness Shear Stress (lbs/in^2) Bot
762	**67.33**	-2341.67	-2518.06	2518.06	11.40	11.60	0.19
782	**105.04**	-1781.25	-2373.61	2373.61	11.01	-28.72	0.04
802	**136.24**	-2238.89	-3020.83	3021.53	14.94	26.38	-0.05
822	**181.71**	-1187.50	-1921.53	1921.53	-22.98	-6.71	0.03
842	**225.10**	-1826.39	-2585.42	2585.42	-25.15	-9.83	-0.14
862	**273.66**	-596.88	-1343.75	1345.83	-42.08	7.39	0.09
882	**323.27**	-1099.31	-1912.50	1912.50	-69.86	-23.39	-0.11
902	**369.20**	657.92	-697.92	1355.56	-103.06	7.99	0.47
922	**419.20**	895.83	-1252.78	1345.14	-187.15	19.38	0.42
942	**444.11**	2200.69	1275.00	2208.33	-271.04	85.00	3.01
962	**471.06**	2671.53	-441.53	2870.83	-311.04	-15.49	2.48
982	**503.51**	2318.06	414.44	2329.17	-372.71	37.83	2.76
1002	**527.76**	4737.50	-747.22	4738.89	-329.17	-28.42	-0.92
1022	**554.76**	5932.64	-291.74	5935.42	-148.40	-11.33	0.29
1042	**582.26**	7430.56	-453.33	7430.56	113.13	-14.49	-0.10
1062	**609.26**	8694.44	-295.90	8694.44	205.97	-12.87	0.10
1082	**636.26**	10430.56	-419.17	10430.56	292.08	-11.06	-0.06
1102	**663.26**	12006.94	-354.17	12006.94	375.07	-10.59	0.05
1122	**688.61**	13791.67	-427.29	13798.61	453.26	25.41	-0.06
1142	**711.96**	15430.56	401.04	15430.56	585.00	-35.32	0.06
1162	**734.96**	15791.67	-418.33	15881.94	585.00	33.03	0.05
1182	**757.91**	16298.61	1430.56	16319.44	636.74	-38.22	0.12
1202	**782.81**	13180.56	-2106.94	14333.33	436.04	-28.91	-0.11
1222	**809.76**	13333.33	77.71	13354.17	460.49	18.54	-0.08
1242	**836.76**	13770.83	-454.44	14229.17	488.47	-22.05	0.14
1262	**863.76**	15381.94	-495.42	15680.56	508.19	-5.48	-0.22
1282	**889.76**	16006.94	4500.00	16006.94	527.57	-18.15	1.00
1302	**906.85**	9736.11	10368.06	10375.00	440.21	151.94	-3.40
1322	**916.04**	-1577.08	-7743.06	7791.67	439.79	442.64	-7.07
1342	**934.63**	-3102.78	-9027.78	9062.50	440.97	11.18	-138.26
1362	**974.63**	1743.75	3035.42	3065.97	-614.86	-3.69	46.46
1382	**1040.78**	612.85	-829.86	1264.58	-215.35	2.25	-28.55
1402	**1110.53**	1290.97	2434.03	2450.00	-264.44	-3.18	40.50

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AY-2D-NL-BES-BEC Pri Tank Stress Gravity Mu=0.4-L.xls, Stress Max

File Listing: Mu=0.0

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 Volume Serial Number is 8785-3B22

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PNNL\2008-006 J-Bolts\Mu-0.0-L

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05/26/2006  01:05 PM    <DIR>          ..
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04/28/2006  11:34 AM           683,520
AY-2D-NL-BES-BEC J Bolt Forces Mu=0.0-
L.xls
05/03/2006  08:05 AM         8,340,992
AY-2D-NL-BES-BEC Pri Tank Stress Gravity
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AY-2D-NL-BES-BEC-J-Bolt-Contact-Mu=0.0-
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04/28/2006  11:26 AM        12,386,304
BES-BEC-Mu-000-L.emat
05/05/2006  11:23 AM           130,982
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04/28/2006  11:25 AM         1,605,361
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05/05/2006  11:23 AM             5,544
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BES-BEC-Mu-000-L.stat
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Boundary.txt
04/25/2006  02:02 PM               195
Contact-AY.txt
12/01/2005  10:11 AM               586
Contact-Footing.txt
09/02/2005  10:28 AM               604
Contact-Insul.txt
04/25/2006  10:56 AM               655
Contact-J-Bolts.txt
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Contact-Primary.txt
09/15/2005  12:50 PM               742
Contact-Soil.txt
09/06/2005  12:16 PM               630
Contact-Waste-AY.txt
01/03/2006  12:17 PM             1,616
Disp-J-Bolts.txt
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file.err
04/28/2006  11:05 AM               912
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Fix-Soil.txt
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04/28/2006  11:26 AM            49,740
Force-c_108th.OUT
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Force-c_117th.OUT
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Force-c_126ath.OUT
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Force-c_126th.OUT
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import_99-180.xls
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10/13/2005  09:28 AM             4,031
interface-gap1.txt
09/09/2005  10:34 AM             2,616
interface1.txt
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Bolt-Contact_0-90.xls
04/28/2006  11:33 AM           101,376 J-
Bolt-Contact_99-180.xls
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Bolt-Cont_108th.OUT
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Bolt-Cont_117max.OUT
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Bolt-Cont_117th.OUT
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Bolt-Cont_126max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_126th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_135max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_135th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_144max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_144th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_153max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_153th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_162max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_162th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_171max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_171th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_180max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_180th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_18max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_18th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_27max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_27th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_36max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_36th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_45max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_45th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_54max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_54th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_63max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_63th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_72max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_72th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_81max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_81th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_90max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_90th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_99max.OUT
04/28/2006  11:26 AM            11,646 J-
Bolt-Cont_99th.OUT
04/28/2006  11:26 AM             3,781 J-
Bolt-Cont_9max.OUT
04/28/2006  11:26 AM            11,774 J-
Bolt-Cont_9th.OUT
06/01/2005  02:17 PM             1,708
Liner.txt
05/26/2006  01:05 PM             7,134
lis.txt
05/02/2005  03:19 PM               667
live_load.txt
11/11/2005  11:38 AM             6,185
Near-Soil-1.txt
04/20/2005  02:14 PM               508
outer-spar.txt
10/31/2005  01:18 PM             5,549
Primary-Props-AY.txt
09/27/2005  04:52 PM             1,538
Primary.txt
04/28/2006  11:05 AM           342,045
QA.out
10/31/2005  11:31 AM             1,108
RS_FREQ.txt
04/28/2006  11:27 AM         3,240,443
Run-Tank-Out.out
04/26/2006  02:42 PM             1,898
Run-Tank.txt
02/11/2005  02:22 PM             1,053
Slave.txt
11/11/2005  11:36 AM             4,989
Soil-Prop-Mean-Geo.txt
04/27/2006  02:15 PM             1,924
Solve-Gravity-BES.txt
10/31/2005  12:02 PM             3,363
spectra-conc-0.txt
```

Date	Time	Size	File
10/14/2005	12:18 PM	2,061	spectra-concrete.txt
10/31/2005	11:17 AM	3,551	spectra-primary-180.txt
09/06/2005	07:49 AM	1,287	spectra-soil.txt
06/20/2005	10:04 AM	647	spectra-wall.txt
06/20/2005	09:52 AM	679	spectra-waste.txt
04/28/2006	12:59 PM	356,352	str-primary_0-90b.xls
04/28/2006	12:59 PM	355,328	str-primary_0-90m.xls
04/28/2006	12:59 PM	353,792	str-primary_0-90t.xls
04/28/2006	12:59 PM	355,328	str-primary_99-180b.xls
04/28/2006	12:59 PM	355,328	str-primary_99-180m.xls
04/28/2006	01:01 PM	354,816	str-primary_99-180t.xls
01/05/2006	04:12 PM	566	strain-compb-p.txt
01/05/2006	04:11 PM	566	strain-compb.txt
01/05/2006	04:13 PM	566	strain-compm-p.txt
09/02/2005	09:51 AM	705	strain-compm.txt
01/05/2006	04:14 PM	578	strain-compt-p.txt
09/02/2005	09:50 AM	720	strain-compt.txt
01/06/2006	10:07 AM	728	Strain-Liner-floor.txt
01/05/2006	04:14 PM	550	Strain-Liner-p.txt
01/06/2006	03:45 PM	823	Strain-Liner-wall.txt
09/02/2005	09:52 AM	544	Strain-Liner.txt
01/06/2006	03:46 PM	274	Strain-Primary.txt
01/06/2006	03:48 PM	246	Strain.txt
01/06/2006	03:41 PM	554	stress-compb-p.txt
09/08/2005	11:18 AM	692	stress-compb.txt
01/06/2006	03:40 PM	554	stress-compm-p.txt
11/01/2005	11:46 AM	702	stress-compm.txt
01/06/2006	03:40 PM	554	stress-compt-p.txt
09/08/2005	10:20 AM	692	stress-compt.txt
04/13/2005	08:38 AM	205	Stress-Primary.txt
04/28/2006	11:27 AM	16,291	Stress-pt_108max-b.OUT
04/28/2006	11:27 AM	16,291	Stress-pt_108max-m.OUT
04/28/2006	11:26 AM	16,210	Stress-pt_108max-t.OUT
04/28/2006	11:27 AM	57,948	Stress-pt_108th-b.OUT
04/28/2006	11:27 AM	57,948	Stress-pt_108th-m.OUT
04/28/2006	11:26 AM	57,752	Stress-pt_108th-t.OUT
04/28/2006	11:27 AM	16,291	Stress-pt_117max-b.OUT
04/28/2006	11:27 AM	16,291	Stress-pt_117max-m.OUT
04/28/2006	11:26 AM	16,210	Stress-pt_117max-t.OUT
04/28/2006	11:27 AM	57,948	Stress-pt_117th-b.OUT
04/28/2006	11:27 AM	57,948	Stress-pt_117th-m.OUT
04/28/2006	11:26 AM	57,752	Stress-pt_117th-t.OUT
04/28/2006	11:27 AM	16,291	Stress-pt_126max-b.OUT
04/28/2006	11:27 AM	16,291	Stress-pt_126max-m.OUT
04/28/2006	11:26 AM	16,210	Stress-pt_126max-t.OUT
04/28/2006	11:27 AM	57,948	Stress-pt_126th-b.OUT
04/28/2006	11:27 AM	57,948	Stress-pt_126th-m.OUT
04/28/2006	11:26 AM	57,752	Stress-pt_126th-t.OUT
04/28/2006	11:27 AM	16,291	Stress-pt_135max-b.OUT
04/28/2006	11:27 AM	16,291	Stress-pt_135max-m.OUT
04/28/2006	11:26 AM	16,210	Stress-pt_135max-t.OUT
04/28/2006	11:27 AM	57,948	Stress-pt_135th-b.OUT
04/28/2006	11:27 AM	57,948	Stress-pt_135th-m.OUT
04/28/2006	11:26 AM	57,752	Stress-pt_135th-t.OUT
04/28/2006	11:27 AM	16,291	Stress-pt_144max-b.OUT
04/28/2006	11:27 AM	16,291	Stress-pt_144max-m.OUT
04/28/2006	11:26 AM	16,210	Stress-pt_144max-t.OUT
04/28/2006	11:27 AM	57,948	Stress-pt_144th-b.OUT
04/28/2006	11:27 AM	57,948	Stress-pt_144th-m.OUT
04/28/2006	11:26 AM	57,752	Stress-pt_144th-t.OUT
04/28/2006	11:27 AM	16,291	Stress-pt_153max-b.OUT
04/28/2006	11:27 AM	16,291	Stress-pt_153max-m.OUT
04/28/2006	11:26 AM	16,210	Stress-pt_153max-t.OUT
04/28/2006	11:27 AM	57,948	Stress-pt_153th-b.OUT
04/28/2006	11:27 AM	57,948	Stress-pt_153th-m.OUT
04/28/2006	11:26 AM	57,752	Stress-pt_153th-t.OUT
04/28/2006	11:27 AM	16,291	Stress-pt_162max-b.OUT
04/28/2006	11:27 AM	16,291	Stress-pt_162max-m.OUT
04/28/2006	11:26 AM	16,210	Stress-pt_162max-t.OUT
04/28/2006	11:27 AM	57,948	Stress-pt_162th-b.OUT

```
04/28/2006  11:27 AM            57,948
Stress-pt_162th-m.OUT
04/28/2006  11:26 AM            57,752
Stress-pt_162th-t.OUT
04/28/2006  11:27 AM            16,295
Stress-pt_171max-b.OUT
04/28/2006  11:27 AM            16,295
Stress-pt_171max-m.OUT
04/28/2006  11:26 AM            16,214
Stress-pt_171max-t.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_171th-b.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_171th-m.OUT
04/28/2006  11:26 AM            57,752
Stress-pt_171th-t.OUT
04/28/2006  11:27 AM            16,295
Stress-pt_180max-b.OUT
04/28/2006  11:27 AM            16,295
Stress-pt_180max-m.OUT
04/28/2006  11:26 AM            16,214
Stress-pt_180max-t.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_180th-b.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_180th-m.OUT
04/28/2006  11:26 AM            57,752
Stress-pt_180th-t.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_18max-b.OUT
04/28/2006  11:26 AM            16,291
Stress-pt_18max-m.OUT
04/28/2006  11:26 AM            16,210
Stress-pt_18max-t.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_18th-b.OUT
04/28/2006  11:26 AM            57,948
Stress-pt_18th-m.OUT
04/28/2006  11:26 AM            57,752
Stress-pt_18th-t.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_27max-b.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_27max-m.OUT
04/28/2006  11:26 AM            16,210
Stress-pt_27max-t.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_27th-b.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_27th-m.OUT
04/28/2006  11:26 AM            57,752
Stress-pt_27th-t.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_36max-b.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_36max-m.OUT
04/28/2006  11:26 AM            16,210
Stress-pt_36max-t.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_36th-b.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_36th-m.OUT
04/28/2006  11:26 AM            57,752
Stress-pt_36th-t.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_45max-b.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_45max-m.OUT
04/28/2006  11:26 AM            16,210
Stress-pt_45max-t.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_45th-b.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_45th-m.OUT
04/28/2006  11:26 AM            57,752
Stress-pt_45th-t.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_54max-b.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_54max-m.OUT
04/28/2006  11:26 AM            16,210
Stress-pt_54max-t.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_54th-b.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_54th-m.OUT
04/28/2006  11:26 AM            57,752
Stress-pt_54th-t.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_63max-b.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_63max-m.OUT
04/28/2006  11:26 AM            16,210
Stress-pt_63max-t.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_63th-b.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_63th-m.OUT
04/28/2006  11:26 AM            57,752
Stress-pt_63th-t.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_72max-b.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_72max-m.OUT
04/28/2006  11:26 AM            16,210
Stress-pt_72max-t.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_72th-b.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_72th-m.OUT
04/28/2006  11:26 AM            57,752
Stress-pt_72th-t.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_81max-b.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_81max-m.OUT
04/28/2006  11:26 AM            16,210
Stress-pt_81max-t.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_81th-b.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_81th-m.OUT
04/28/2006  11:26 AM            57,752
Stress-pt_81th-t.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_90max-b.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_90max-m.OUT
04/28/2006  11:26 AM            16,210
Stress-pt_90max-t.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_90th-b.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_90th-m.OUT
04/28/2006  11:26 AM            57,752
Stress-pt_90th-t.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_99max-b.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_99max-m.OUT
```

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04/28/2006  11:26 AM            16,210
Stress-pt_99max-t.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_99th-b.OUT
04/28/2006  11:27 AM            57,948
Stress-pt_99th-m.OUT
04/28/2006  11:26 AM            57,752
Stress-pt_99th-t.OUT
04/28/2006  11:27 AM            16,291
Stress-pt_9max-b.OUT
04/28/2006  11:26 AM            16,291
Stress-pt_9max-m.OUT
04/28/2006  11:26 AM            16,210
Stress-pt_9max-t.OUT
04/28/2006  11:27 AM            58,076
Stress-pt_9th-b.OUT
04/28/2006  11:26 AM            58,076
Stress-pt_9th-m.OUT
04/28/2006  11:26 AM            57,880
Stress-pt_9th-t.OUT
10/31/2005  01:13 PM             3,825
Tank-Coordinates-AY.txt
05/25/2005  04:32 PM             2,512
Tank-Mesh1.txt
04/28/2006  11:05 AM               102
tank-out.out
02/25/2005  03:24 PM             5,406
Tank-Props-BEC-250.txt
04/28/2006  11:05 AM             4,692
Tank-th.out
12/22/2005  01:43 PM            10,035
temp.log
05/16/2005  04:40 PM            41,470
TH-266-Mean-Geo-V.txt
05/13/2005  11:57 AM            41,472
TH-266-Mean-Geo.txt
11/01/2005  01:19 PM               342
Waste-Reaction.txt
10/31/2005  01:01 PM             3,265
Waste-solid-AY.txt
04/24/2006  11:35 AM               240
Zero-Friction.log
             364 File(s)    656,904,556
bytes
               2 Dir(s)  154,616,926,208
bytes free
```

File Listing: Mu=0.1

```
 Volume in drive C is 600GB 2xRAID0
 Volume Serial Number is 8785-3B22

 Directory of C:\Users\Bruce\2008-000
PNNL\2008-006 J-Bolts\Mu-0.1-L

05/26/2006  01:05 PM    <DIR>          .
05/26/2006  01:05 PM    <DIR>          ..
04/25/2006  02:02 PM               100
All-Forces.txt
04/28/2006  11:32 AM           685,568
AY-2D-NL-BES-BEC J Bolt Forces Mu=0.1-
L.xls
05/02/2006  11:13 AM           903,168
AY-2D-NL-BES-BEC-J-Bolt-Contact-Mu=0.1-
L.xls
04/28/2006  11:04 AM            72,158
BEC-BES-Gravity-Dome-F-010-L.out
04/28/2006  11:04 AM             2,998
BES-BEC-Mu-010-L.BCS
04/28/2006  11:05 AM        35,717,120
BES-BEC-Mu-010-L.db
04/28/2006  11:04 AM        12,386,304
BES-BEC-Mu-010-L.emat
04/28/2006  11:04 AM           119,268
BES-BEC-Mu-010-L.err
04/28/2006  11:04 AM       102,563,840
BES-BEC-Mu-010-L.esav
04/28/2006  11:04 AM        27,852,800
BES-BEC-Mu-010-L.full
04/28/2006  11:03 AM         1,605,361
BES-BEC-Mu-010-L.ldhi
04/28/2006  10:43 AM               234
BES-BEC-Mu-010-L.log
04/28/2006  11:04 AM             2,295
BES-BEC-Mu-010-L.mntr
04/28/2006  11:03 AM       102,563,840
BES-BEC-Mu-010-L.osav
04/28/2006  11:04 AM             1,411
BES-BEC-Mu-010-L.PVTS
04/28/2006  11:04 AM       103,546,880
BES-BEC-Mu-010-L.r001
04/28/2006  10:44 AM        35,782,656
BES-BEC-Mu-010-L.rdb
04/28/2006  11:04 AM       207,421,440
BES-BEC-Mu-010-L.rst
04/28/2006  11:02 AM               289
BES-BEC-Mu-010-L.stat
04/25/2006  05:25 PM                78
BES-BEC-Mu-010.log
04/28/2006  09:56 AM             5,788
Bolts-Friction.txt
06/09/2005  02:59 PM               262
Boundary.txt
04/25/2006  02:02 PM               195
Contact-AY.txt
12/01/2005  10:11 AM               586
Contact-Footing.txt
09/02/2005  10:28 AM               604
Contact-Insul.txt
04/25/2006  10:56 AM               655
Contact-J-Bolts.txt
09/09/2005  10:59 AM               608
Contact-Primary.txt
09/15/2005  12:50 PM               742
Contact-Soil.txt
09/06/2005  12:16 PM               630
Contact-Waste-AY.txt
01/03/2006  12:17 PM             1,616
Disp-J-Bolts.txt
09/22/2005  05:05 PM             8,608
Far-Soil.txt
04/28/2006  10:43 AM             1,988
file.bat
04/28/2006  10:43 AM               272
file.err
04/28/2006  10:43 AM             3,380
file.log
10/13/2005  07:54 AM               562
Fix-Soil.txt
04/06/2005  09:24 AM               894
Force-c.txt
04/28/2006  11:04 AM             4,996
Force-c_108amax.OUT
04/28/2006  11:04 AM            27,900
Force-c_108ath.OUT
04/28/2006  11:04 AM            14,716
Force-c_108max.OUT
04/28/2006  11:04 AM            49,740
Force-c_108th.OUT
```

04/28/2006 11:04 AM	4,996	Force-c_117amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_117ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_117max.OUT
04/28/2006 11:04 AM	49,740	Force-c_117th.OUT
04/28/2006 11:04 AM	4,996	Force-c_126amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_126ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_126max.OUT
04/28/2006 11:04 AM	49,740	Force-c_126th.OUT
04/28/2006 11:04 AM	4,996	Force-c_135amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_135ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_135max.OUT
04/28/2006 11:04 AM	49,740	Force-c_135th.OUT
04/28/2006 11:04 AM	4,996	Force-c_144amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_144ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_144max.OUT
04/28/2006 11:04 AM	49,740	Force-c_144th.OUT
04/28/2006 11:04 AM	4,996	Force-c_153amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_153ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_153max.OUT
04/28/2006 11:04 AM	49,740	Force-c_153th.OUT
04/28/2006 11:04 AM	4,996	Force-c_162amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_162ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_162max.OUT
04/28/2006 11:04 AM	49,740	Force-c_162th.OUT
04/28/2006 11:04 AM	4,996	Force-c_171amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_171ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_171max.OUT
04/28/2006 11:04 AM	49,740	Force-c_171th.OUT
04/28/2006 11:04 AM	4,996	Force-c_180amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_180ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_180max.OUT
04/28/2006 11:04 AM	49,740	Force-c_180th.OUT
04/28/2006 11:04 AM	4,996	Force-c_18amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_18ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_18max.OUT
04/28/2006 11:04 AM	49,740	Force-c_18th.OUT
04/28/2006 11:04 AM	4,996	Force-c_27amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_27ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_27max.OUT
04/28/2006 11:04 AM	49,740	Force-c_27th.OUT
04/28/2006 11:04 AM	4,996	Force-c_36amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_36ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_36max.OUT
04/28/2006 11:04 AM	49,740	Force-c_36th.OUT
04/28/2006 11:04 AM	4,996	Force-c_45amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_45ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_45max.OUT
04/28/2006 11:04 AM	49,740	Force-c_45th.OUT
04/28/2006 11:04 AM	4,996	Force-c_54amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_54ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_54max.OUT
04/28/2006 11:04 AM	49,740	Force-c_54th.OUT
04/28/2006 11:04 AM	4,996	Force-c_63amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_63ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_63max.OUT
04/28/2006 11:04 AM	49,740	Force-c_63th.OUT
04/28/2006 11:04 AM	4,996	Force-c_72amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_72ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_72max.OUT
04/28/2006 11:04 AM	49,740	Force-c_72th.OUT
04/28/2006 11:04 AM	4,996	Force-c_81amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_81ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_81max.OUT
04/28/2006 11:04 AM	49,740	Force-c_81th.OUT
04/28/2006 11:04 AM	4,996	Force-c_90amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_90ath.OUT
04/28/2006 11:04 AM	14,716	Force-c_90max.OUT
04/28/2006 11:04 AM	49,740	Force-c_90th.OUT
04/28/2006 11:04 AM	4,996	Force-c_99amax.OUT
04/28/2006 11:04 AM	27,900	Force-c_99ath.OUT

```
04/28/2006  11:04 AM          14,716
Force-c_99max.OUT
04/28/2006  11:04 AM          49,740
Force-c_99th.OUT
04/28/2006  11:04 AM           4,996
Force-c_9amax.OUT
04/28/2006  11:04 AM          28,028
Force-c_9ath.OUT
04/28/2006  11:04 AM          14,716
Force-c_9max.OUT
04/28/2006  11:04 AM          49,868
Force-c_9th.OUT
04/28/2006  11:32 AM         142,336
force-jb.xls
04/28/2006  11:05 AM          23,352
Force-jb_r10-th.OUT
04/28/2006  11:05 AM           5,239
Force-jb_r10_max.OUT
04/28/2006  11:05 AM          23,352
Force-jb_r11-th.OUT
04/28/2006  11:05 AM           5,239
Force-jb_r11_max.OUT
04/28/2006  11:05 AM          23,480
Force-jb_r2-th.OUT
04/28/2006  11:05 AM           5,239
Force-jb_r2_max.OUT
04/28/2006  11:05 AM          23,352
Force-jb_r3-th.OUT
04/28/2006  11:05 AM           5,239
Force-jb_r3_max.OUT
04/28/2006  11:05 AM          23,352
Force-jb_r4-th.OUT
04/28/2006  11:05 AM           5,239
Force-jb_r4_max.OUT
04/28/2006  11:05 AM          23,352
Force-jb_r5-th.OUT
04/28/2006  11:05 AM           5,239
Force-jb_r5_max.OUT
04/28/2006  11:05 AM          23,352
Force-jb_r6-th.OUT
04/28/2006  11:05 AM           5,239
Force-jb_r6_max.OUT
04/28/2006  11:05 AM          23,352
Force-jb_r7-th.OUT
04/28/2006  11:05 AM           5,239
Force-jb_r7_max.OUT
04/28/2006  11:05 AM          23,352
Force-jb_r8-th.OUT
04/28/2006  11:05 AM           5,239
Force-jb_r8_max.OUT
04/28/2006  11:05 AM          23,352
Force-jb_r9-th.OUT
04/28/2006  11:05 AM           5,239
Force-jb_r9_max.OUT
06/20/2005  11:53 AM             661
Force-j_bolt.txt
09/01/2005  11:27 AM           1,664
Insulate.txt
10/13/2005  09:28 AM           4,031
interface-gap1.txt
09/09/2005  10:34 AM           2,616
interface1.txt
04/28/2006  11:31 AM         100,864 J-
Bolt-Contact_0-90.xls
04/28/2006  11:31 AM         101,376 J-
Bolt-Contact_99-180.xls
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_108max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_108th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_117max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_117th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_126max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_126th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_135max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_135th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_144max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_144th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_153max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_153th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_162max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_162th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_171max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_171th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_180max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_180th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_18max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_18th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_27max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_27th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_36max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_36th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_45max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_45th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_54max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_54th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_63max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_63th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_72max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_72th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_81max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_81th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_90max.OUT
04/28/2006  11:04 AM          11,646 J-
Bolt-Cont_90th.OUT
04/28/2006  11:04 AM           3,781 J-
Bolt-Cont_99max.OUT
```

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04/28/2006  11:04 AM            11,646 J-
Bolt-Cont_99th.OUT
04/28/2006  11:04 AM             3,781 J-
Bolt-Cont_9max.OUT
04/28/2006  11:04 AM            11,774 J-
Bolt-Cont_9th.OUT
06/01/2005  02:17 PM             1,708
Liner.txt
05/26/2006  01:05 PM                 0
lis.txt
05/02/2005  03:19 PM               667
live_load.txt
11/11/2005  11:38 AM             6,185
Near-Soil-1.txt
04/20/2005  02:14 PM               508
outer-spar.txt
10/31/2005  01:18 PM             5,549
Primary-Props-AY.txt
09/27/2005  04:52 PM             1,538
Primary.txt
04/28/2006  10:43 AM           342,045
QA.out
10/31/2005  11:31 AM             1,108
RS_FREQ.txt
04/28/2006  11:05 AM         3,240,443
Run-Tank-Out.out
04/26/2006  02:44 PM             1,898
Run-Tank.txt
02/11/2005  02:22 PM             1,053
Slave.txt
11/11/2005  11:36 AM             4,989
Soil-Prop-Mean-Geo.txt
04/27/2006  02:15 PM             1,924
Solve-Gravity-BES.txt
10/31/2005  12:02 PM             3,363
spectra-conc-0.txt
10/14/2005  12:18 PM             2,061
spectra-concrete.txt
10/31/2005  11:17 AM             3,551
spectra-primary-180.txt
09/06/2005  07:49 AM             1,287
spectra-soil.txt
06/20/2005  10:04 AM               647
spectra-wall.txt
06/20/2005  09:52 AM               679
spectra-waste.txt
01/05/2006  04:12 PM               566
strain-compb-p.txt
01/05/2006  04:11 PM               566
strain-compb.txt
01/05/2006  04:13 PM               566
strain-compm-p.txt
09/02/2005  09:51 AM               705
strain-compm.txt
01/05/2006  04:14 PM               578
strain-compt-p.txt
09/02/2005  09:50 AM               720
strain-compt.txt
01/06/2006  10:07 AM               728
Strain-Liner-floor.txt
01/05/2006  04:14 PM               550
Strain-Liner-p.txt
01/06/2006  03:45 PM               823
Strain-Liner-wall.txt
09/02/2005  09:52 AM               544
Strain-Liner.txt
01/06/2006  03:46 PM               274
Strain-Primary.txt
01/06/2006  03:48 PM               246
Strain.txt
01/06/2006  03:41 PM               554
stress-compb-p.txt
09/08/2005  11:18 AM               692
stress-compb.txt
01/06/2006  03:40 PM               554
stress-compm-p.txt
11/01/2005  11:46 AM               702
stress-compm.txt
01/06/2006  03:40 PM               554
stress-compt-p.txt
09/08/2005  10:20 AM               692
stress-compt.txt
04/13/2005  08:38 AM               205
Stress-Primary.txt
04/28/2006  11:05 AM            16,291
Stress-pt_108max-b.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_108max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_108max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_108th-b.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_108th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_108th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_117max-b.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_117max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_117max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_117th-b.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_117th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_117th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_126max-b.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_126max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_126max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_126th-b.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_126th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_126th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_135max-b.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_135max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_135max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_135th-b.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_135th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_135th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_144max-b.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_144max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_144max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_144th-b.OUT
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04/28/2006  11:05 AM            57,948
Stress-pt_144th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_144th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_153max-b.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_153max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_153max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_153th-b.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_153th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_153th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_162max-b.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_162max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_162max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_162th-b.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_162th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_162th-t.OUT
04/28/2006  11:05 AM            16,295
Stress-pt_171max-b.OUT
04/28/2006  11:05 AM            16,295
Stress-pt_171max-m.OUT
04/28/2006  11:04 AM            16,214
Stress-pt_171max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_171th-b.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_171th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_171th-t.OUT
04/28/2006  11:05 AM            16,295
Stress-pt_180max-b.OUT
04/28/2006  11:05 AM            16,295
Stress-pt_180max-m.OUT
04/28/2006  11:04 AM            16,214
Stress-pt_180max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_180th-b.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_180th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_180th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_18max-b.OUT
04/28/2006  11:04 AM            16,291
Stress-pt_18max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_18max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_18th-b.OUT
04/28/2006  11:04 AM            57,948
Stress-pt_18th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_18th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_27max-b.OUT
04/28/2006  11:04 AM            16,291
Stress-pt_27max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_27max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_27th-b.OUT
04/28/2006  11:04 AM            57,948
Stress-pt_27th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_27th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_36max-b.OUT
04/28/2006  11:04 AM            16,291
Stress-pt_36max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_36max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_36th-b.OUT
04/28/2006  11:04 AM            57,948
Stress-pt_36th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_36th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_45max-b.OUT
04/28/2006  11:04 AM            16,291
Stress-pt_45max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_45max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_45th-b.OUT
04/28/2006  11:04 AM            57,948
Stress-pt_45th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_45th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_54max-b.OUT
04/28/2006  11:04 AM            16,291
Stress-pt_54max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_54max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_54th-b.OUT
04/28/2006  11:04 AM            57,948
Stress-pt_54th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_54th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_63max-b.OUT
04/28/2006  11:04 AM            16,291
Stress-pt_63max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_63max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_63th-b.OUT
04/28/2006  11:04 AM            57,948
Stress-pt_63th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_63th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_72max-b.OUT
04/28/2006  11:04 AM            16,291
Stress-pt_72max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_72max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_72th-b.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_72th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_72th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_81max-b.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_81max-m.OUT
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04/28/2006  11:04 AM            16,210
Stress-pt_81max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_81th-b.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_81th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_81th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_90max-b.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_90max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_90max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_90th-b.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_90th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_90th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_99max-b.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_99max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_99max-t.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_99th-b.OUT
04/28/2006  11:05 AM            57,948
Stress-pt_99th-m.OUT
04/28/2006  11:04 AM            57,752
Stress-pt_99th-t.OUT
04/28/2006  11:05 AM            16,291
Stress-pt_9max-b.OUT
04/28/2006  11:04 AM            16,291
Stress-pt_9max-m.OUT
04/28/2006  11:04 AM            16,210
Stress-pt_9max-t.OUT
04/28/2006  11:05 AM            58,076
Stress-pt_9th-b.OUT
04/28/2006  11:04 AM            58,076
Stress-pt_9th-m.OUT
04/28/2006  11:04 AM            57,880
Stress-pt_9th-t.OUT
10/31/2005  01:13 PM             3,825
Tank-Coordinates-AY.txt
05/25/2005  04:32 PM             2,512
Tank-Mesh1.txt
04/28/2006  10:43 AM               102
tank-out.out
02/25/2005  03:24 PM             5,406
Tank-Props-BEC-250.txt
04/28/2006  10:43 AM             4,692
Tank-th.out
12/22/2005  01:43 PM            10,035
temp.log
05/16/2005  04:40 PM            41,470
TH-266-Mean-Geo-V.txt
05/13/2005  11:57 AM            41,472
TH-266-Mean-Geo.txt
11/01/2005  01:19 PM               342
Waste-Reaction.txt
10/31/2005  01:01 PM             3,265
Waste-solid-AY.txt
04/24/2006  11:35 AM               240
Zero-Friction.log
             353 File(s)    642,345,339
bytes
               2 Dir(s)  154,590,937,088
bytes free
```

File Listing: Mu=0.2

```
 Volume in drive C is 600GB 2xRAID0
 Volume Serial Number is 8785-3B22

 Directory of C:\Users\Bruce\2008-000
PNNL\2008-006 J-Bolts\Mu-0.2-L

05/26/2006  01:05 PM    <DIR>          .
05/26/2006  01:05 PM    <DIR>          ..
04/25/2006  02:02 PM               100
All-Forces.txt
04/28/2006  11:30 AM           685,568
AY-2D-NL-BES-BEC J Bolt Forces Mu=0.2-
L.xls
05/02/2006  11:09 AM           903,168
AY-2D-NL-BES-BEC-J-Bolt-Contact-Mu=0.2-
L.xls
04/28/2006  10:42 AM            72,158
BEC-BES-Gravity-Dome-F-020-L.out
04/28/2006  08:21 AM         1,022,464
BES-BEC-Mu-020-L.avi
04/28/2006  10:42 AM             2,998
BES-BEC-Mu-020-L.BCS
04/28/2006  10:43 AM        35,717,120
BES-BEC-Mu-020-L.db
04/28/2006  10:42 AM        12,386,304
BES-BEC-Mu-020-L.emat
04/28/2006  10:43 AM           135,395
BES-BEC-Mu-020-L.err
04/28/2006  10:42 AM       102,563,840
BES-BEC-Mu-020-L.esav
04/28/2006  10:42 AM        27,852,800
BES-BEC-Mu-020-L.full
04/28/2006  10:41 AM         1,605,361
BES-BEC-Mu-020-L.ldhi
04/28/2006  10:21 AM             1,370
BES-BEC-Mu-020-L.log
04/28/2006  10:42 AM             2,295
BES-BEC-Mu-020-L.mntr
04/28/2006  10:41 AM       102,563,840
BES-BEC-Mu-020-L.osav
04/28/2006  10:42 AM             1,411
BES-BEC-Mu-020-L.PVTS
04/28/2006  10:42 AM       103,546,880
BES-BEC-Mu-020-L.r001
04/28/2006  10:21 AM        35,782,656
BES-BEC-Mu-020-L.rdb
04/28/2006  10:42 AM       207,421,440
BES-BEC-Mu-020-L.rst
04/28/2006  10:40 AM                97
BES-BEC-Mu-020-L.stat
04/25/2006  05:04 PM                78
BES-BEC-Mu-020.log
04/28/2006  09:56 AM             5,789
Bolts-Friction.txt
06/09/2005  02:59 PM               262
Boundary.txt
04/25/2006  02:02 PM               195
Contact-AY.txt
12/01/2005  10:11 AM               586
Contact-Footing.txt
09/02/2005  10:28 AM               604
Contact-Insul.txt
04/25/2006  10:56 AM               655
Contact-J-Bolts.txt
09/09/2005  10:59 AM               608
Contact-Primary.txt
```

09/15/2005 12:50 PM	742	Contact-Soil.txt
09/06/2005 12:16 PM	630	Contact-Waste-AY.txt
01/03/2006 12:17 PM	1,616	Disp-J-Bolts.txt
09/22/2005 05:05 PM	8,608	Far-Soil.txt
04/28/2006 10:21 AM	1,988	file.bat
04/28/2006 10:21 AM	272	file.err
04/28/2006 10:21 AM	3,380	file.log
10/13/2005 07:54 AM	562	Fix-Soil.txt
04/06/2005 09:24 AM	894	Force-c.txt
04/28/2006 10:42 AM	4,996	Force-c_108amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_108ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_108max.OUT
04/28/2006 10:42 AM	49,740	Force-c_108th.OUT
04/28/2006 10:42 AM	4,996	Force-c_117amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_117ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_117max.OUT
04/28/2006 10:42 AM	49,740	Force-c_117th.OUT
04/28/2006 10:42 AM	4,996	Force-c_126amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_126ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_126max.OUT
04/28/2006 10:42 AM	49,740	Force-c_126th.OUT
04/28/2006 10:42 AM	4,996	Force-c_135amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_135ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_135max.OUT
04/28/2006 10:42 AM	49,740	Force-c_135th.OUT
04/28/2006 10:42 AM	4,996	Force-c_144amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_144ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_144max.OUT
04/28/2006 10:42 AM	49,740	Force-c_144th.OUT
04/28/2006 10:42 AM	4,996	Force-c_153amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_153ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_153max.OUT
04/28/2006 10:42 AM	49,740	Force-c_153th.OUT
04/28/2006 10:42 AM	4,996	Force-c_162amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_162ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_162max.OUT
04/28/2006 10:42 AM	49,740	Force-c_162th.OUT
04/28/2006 10:42 AM	4,996	Force-c_171amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_171ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_171max.OUT
04/28/2006 10:42 AM	49,740	Force-c_171th.OUT
04/28/2006 10:42 AM	4,996	Force-c_180amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_180ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_180max.OUT
04/28/2006 10:42 AM	49,740	Force-c_180th.OUT
04/28/2006 10:42 AM	4,996	Force-c_18amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_18ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_18max.OUT
04/28/2006 10:42 AM	49,740	Force-c_18th.OUT
04/28/2006 10:42 AM	4,996	Force-c_27amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_27ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_27max.OUT
04/28/2006 10:42 AM	49,740	Force-c_27th.OUT
04/28/2006 10:42 AM	4,996	Force-c_36amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_36ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_36max.OUT
04/28/2006 10:42 AM	49,740	Force-c_36th.OUT
04/28/2006 10:42 AM	4,996	Force-c_45amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_45ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_45max.OUT
04/28/2006 10:42 AM	49,740	Force-c_45th.OUT
04/28/2006 10:42 AM	4,996	Force-c_54amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_54ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_54max.OUT
04/28/2006 10:42 AM	49,740	Force-c_54th.OUT
04/28/2006 10:42 AM	4,996	Force-c_63amax.OUT
04/28/2006 10:42 AM	27,900	Force-c_63ath.OUT
04/28/2006 10:42 AM	14,716	Force-c_63max.OUT
04/28/2006 10:42 AM	49,740	Force-c_63th.OUT
04/28/2006 10:42 AM	4,996	Force-c_72amax.OUT

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04/28/2006  10:42 AM              27,900
Force-c_72ath.OUT
04/28/2006  10:42 AM              14,716
Force-c_72max.OUT
04/28/2006  10:42 AM              49,740
Force-c_72th.OUT
04/28/2006  10:42 AM               4,996
Force-c_81amax.OUT
04/28/2006  10:42 AM              27,900
Force-c_81ath.OUT
04/28/2006  10:42 AM              14,716
Force-c_81max.OUT
04/28/2006  10:42 AM              49,740
Force-c_81th.OUT
04/28/2006  10:42 AM               4,996
Force-c_90amax.OUT
04/28/2006  10:42 AM              27,900
Force-c_90ath.OUT
04/28/2006  10:42 AM              14,716
Force-c_90max.OUT
04/28/2006  10:42 AM              49,740
Force-c_90th.OUT
04/28/2006  10:42 AM               4,996
Force-c_99amax.OUT
04/28/2006  10:42 AM              27,900
Force-c_99ath.OUT
04/28/2006  10:42 AM              14,716
Force-c_99max.OUT
04/28/2006  10:42 AM              49,740
Force-c_99th.OUT
04/28/2006  10:42 AM               4,996
Force-c_9amax.OUT
04/28/2006  10:42 AM              28,028
Force-c_9ath.OUT
04/28/2006  10:42 AM              14,716
Force-c_9max.OUT
04/28/2006  10:42 AM              49,868
Force-c_9th.OUT
04/28/2006  11:29 AM             136,192
force-jb.xls
04/28/2006  10:43 AM              23,352
Force-jb_r10-th.OUT
04/28/2006  10:43 AM               5,239
Force-jb_r10_max.OUT
04/28/2006  10:43 AM              23,352
Force-jb_r11-th.OUT
04/28/2006  10:43 AM               5,239
Force-jb_r11_max.OUT
04/28/2006  10:43 AM              23,480
Force-jb_r2-th.OUT
04/28/2006  10:43 AM               5,239
Force-jb_r2_max.OUT
04/28/2006  10:43 AM              23,352
Force-jb_r3-th.OUT
04/28/2006  10:43 AM               5,239
Force-jb_r3_max.OUT
04/28/2006  10:43 AM              23,352
Force-jb_r4-th.OUT
04/28/2006  10:43 AM               5,239
Force-jb_r4_max.OUT
04/28/2006  10:43 AM              23,352
Force-jb_r5-th.OUT
04/28/2006  10:43 AM               5,239
Force-jb_r5_max.OUT
04/28/2006  10:43 AM              23,352
Force-jb_r6-th.OUT
04/28/2006  10:43 AM               5,239
Force-jb_r6_max.OUT
04/28/2006  10:43 AM              23,352
Force-jb_r7-th.OUT
04/28/2006  10:43 AM               5,239
Force-jb_r7_max.OUT
04/28/2006  10:43 AM              23,352
Force-jb_r8-th.OUT
04/28/2006  10:43 AM               5,239
Force-jb_r8_max.OUT
04/28/2006  10:43 AM              23,352
Force-jb_r9-th.OUT
04/28/2006  10:43 AM               5,239
Force-jb_r9_max.OUT
06/20/2005  11:53 AM                 661
Force-j_bolt.txt
09/01/2005  11:27 AM               1,664
Insulate.txt
10/13/2005  09:28 AM               4,031
interface-gap1.txt
09/09/2005  10:34 AM               2,616
interface1.txt
04/28/2006  11:28 AM             101,376 J-
Bolt-Contact_0-90.xls
04/28/2006  11:28 AM             101,376 J-
Bolt-Contact_99-180.xls
04/28/2006  10:42 AM               3,781 J-
Bolt-Cont_108max.OUT
04/28/2006  10:42 AM              11,646 J-
Bolt-Cont_108th.OUT
04/28/2006  10:42 AM               3,781 J-
Bolt-Cont_117max.OUT
04/28/2006  10:42 AM              11,646 J-
Bolt-Cont_117th.OUT
04/28/2006  10:42 AM               3,781 J-
Bolt-Cont_126max.OUT
04/28/2006  10:42 AM              11,646 J-
Bolt-Cont_126th.OUT
04/28/2006  10:42 AM               3,781 J-
Bolt-Cont_135max.OUT
04/28/2006  10:42 AM              11,646 J-
Bolt-Cont_135th.OUT
04/28/2006  10:42 AM               3,781 J-
Bolt-Cont_144max.OUT
04/28/2006  10:42 AM              11,646 J-
Bolt-Cont_144th.OUT
04/28/2006  10:42 AM               3,781 J-
Bolt-Cont_153max.OUT
04/28/2006  10:42 AM              11,646 J-
Bolt-Cont_153th.OUT
04/28/2006  10:42 AM               3,781 J-
Bolt-Cont_162max.OUT
04/28/2006  10:42 AM              11,646 J-
Bolt-Cont_162th.OUT
04/28/2006  10:42 AM               3,781 J-
Bolt-Cont_171max.OUT
04/28/2006  10:42 AM              11,646 J-
Bolt-Cont_171th.OUT
04/28/2006  10:42 AM               3,781 J-
Bolt-Cont_180max.OUT
04/28/2006  10:42 AM              11,646 J-
Bolt-Cont_180th.OUT
04/28/2006  10:42 AM               3,781 J-
Bolt-Cont_18max.OUT
04/28/2006  10:42 AM              11,646 J-
Bolt-Cont_18th.OUT
04/28/2006  10:42 AM               3,781 J-
Bolt-Cont_27max.OUT
04/28/2006  10:42 AM              11,646 J-
Bolt-Cont_27th.OUT
04/28/2006  10:42 AM               3,781 J-
Bolt-Cont_36max.OUT
04/28/2006  10:42 AM              11,646 J-
Bolt-Cont_36th.OUT
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04/28/2006  10:42 AM             3,781 J-
Bolt-Cont_45max.OUT
04/28/2006  10:42 AM            11,646 J-
Bolt-Cont_45th.OUT
04/28/2006  10:42 AM             3,781 J-
Bolt-Cont_54max.OUT
04/28/2006  10:42 AM            11,646 J-
Bolt-Cont_54th.OUT
04/28/2006  10:42 AM             3,781 J-
Bolt-Cont_63max.OUT
04/28/2006  10:42 AM            11,646 J-
Bolt-Cont_63th.OUT
04/28/2006  10:42 AM             3,781 J-
Bolt-Cont_72max.OUT
04/28/2006  10:42 AM            11,646 J-
Bolt-Cont_72th.OUT
04/28/2006  10:42 AM             3,781 J-
Bolt-Cont_81max.OUT
04/28/2006  10:42 AM            11,646 J-
Bolt-Cont_81th.OUT
04/28/2006  10:42 AM             3,781 J-
Bolt-Cont_90max.OUT
04/28/2006  10:42 AM            11,646 J-
Bolt-Cont_90th.OUT
04/28/2006  10:42 AM             3,781 J-
Bolt-Cont_99max.OUT
04/28/2006  10:42 AM            11,646 J-
Bolt-Cont_99th.OUT
04/28/2006  10:42 AM             3,781 J-
Bolt-Cont_9max.OUT
04/28/2006  10:42 AM            11,774 J-
Bolt-Cont_9th.OUT
06/01/2005  02:17 PM             1,708
Liner.txt
05/26/2006  01:05 PM                 0
lis.txt
05/02/2005  03:19 PM               667
live_load.txt
11/11/2005  11:38 AM             6,185
Near-Soil-1.txt
04/20/2005  02:14 PM               508
outer-spar.txt
10/31/2005  01:18 PM             5,549
Primary-Props-AY.txt
09/27/2005  04:52 PM             1,538
Primary.txt
04/28/2006  10:21 AM           342,045
QA.out
10/31/2005  11:31 AM             1,108
RS_FREQ.txt
04/28/2006  10:43 AM         3,240,443
Run-Tank-Out.out
04/26/2006  02:44 PM             1,898
Run-Tank.txt
02/11/2005  02:22 PM             1,053
Slave.txt
11/11/2005  11:36 AM             4,989
Soil-Prop-Mean-Geo.txt
04/27/2006  02:15 PM             1,924
Solve-Gravity-BES.txt
10/31/2005  12:02 PM             3,363
spectra-conc-0.txt
10/14/2005  12:18 PM             2,061
spectra-concrete.txt
10/31/2005  11:17 AM             3,551
spectra-primary-180.txt
09/06/2005  07:49 AM             1,287
spectra-soil.txt
06/20/2005  10:04 AM               647
spectra-wall.txt
06/20/2005  09:52 AM               679
spectra-waste.txt
01/05/2006  04:12 PM               566
strain-compb-p.txt
01/05/2006  04:11 PM               566
strain-compb.txt
01/05/2006  04:13 PM               566
strain-compm-p.txt
09/02/2005  09:51 AM               705
strain-compm.txt
01/05/2006  04:14 PM               578
strain-compt-p.txt
09/02/2005  09:50 AM               720
strain-compt.txt
01/06/2006  10:07 AM               728
Strain-Liner-floor.txt
01/05/2006  04:14 PM               550
Strain-Liner-p.txt
01/06/2006  03:45 PM               823
Strain-Liner-wall.txt
09/02/2005  09:52 AM               544
Strain-Liner.txt
01/06/2006  03:46 PM               274
Strain-Primary.txt
01/06/2006  03:48 PM               246
Strain.txt
01/06/2006  03:41 PM               554
stress-compb-p.txt
09/08/2005  11:18 AM               692
stress-compb.txt
01/06/2006  03:40 PM               554
stress-compm-p.txt
11/01/2005  11:46 AM               702
stress-compm.txt
01/06/2006  03:40 PM               554
stress-compt-p.txt
09/08/2005  10:20 AM               692
stress-compt.txt
04/13/2005  08:38 AM               205
Stress-Primary.txt
04/28/2006  10:43 AM            16,291
Stress-pt_108max-b.OUT
04/28/2006  10:43 AM            16,291
Stress-pt_108max-m.OUT
04/28/2006  10:42 AM            16,210
Stress-pt_108max-t.OUT
04/28/2006  10:43 AM            57,948
Stress-pt_108th-b.OUT
04/28/2006  10:43 AM            57,948
Stress-pt_108th-m.OUT
04/28/2006  10:42 AM            57,752
Stress-pt_108th-t.OUT
04/28/2006  10:43 AM            16,291
Stress-pt_117max-b.OUT
04/28/2006  10:43 AM            16,291
Stress-pt_117max-m.OUT
04/28/2006  10:42 AM            16,210
Stress-pt_117max-t.OUT
04/28/2006  10:43 AM            57,948
Stress-pt_117th-b.OUT
04/28/2006  10:43 AM            57,948
Stress-pt_117th-m.OUT
04/28/2006  10:42 AM            57,752
Stress-pt_117th-t.OUT
04/28/2006  10:43 AM            16,291
Stress-pt_126max-b.OUT
04/28/2006  10:43 AM            16,291
Stress-pt_126max-m.OUT
04/28/2006  10:42 AM            16,210
Stress-pt_126max-t.OUT
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04/28/2006 10:43 AM 57,948 Stress-pt_126th-b.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_126th-m.OUT
04/28/2006 10:42 AM 57,752 Stress-pt_126th-t.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_135max-b.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_135max-m.OUT
04/28/2006 10:42 AM 16,210 Stress-pt_135max-t.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_135th-b.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_135th-m.OUT
04/28/2006 10:42 AM 57,752 Stress-pt_135th-t.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_144max-b.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_144max-m.OUT
04/28/2006 10:42 AM 16,210 Stress-pt_144max-t.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_144th-b.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_144th-m.OUT
04/28/2006 10:42 AM 57,752 Stress-pt_144th-t.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_153max-b.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_153max-m.OUT
04/28/2006 10:42 AM 16,210 Stress-pt_153max-t.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_153th-b.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_153th-m.OUT
04/28/2006 10:42 AM 57,752 Stress-pt_153th-t.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_162max-b.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_162max-m.OUT
04/28/2006 10:42 AM 16,210 Stress-pt_162max-t.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_162th-b.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_162th-m.OUT
04/28/2006 10:42 AM 57,752 Stress-pt_162th-t.OUT
04/28/2006 10:43 AM 16,295 Stress-pt_171max-b.OUT
04/28/2006 10:43 AM 16,295 Stress-pt_171max-m.OUT
04/28/2006 10:42 AM 16,214 Stress-pt_171max-t.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_171th-b.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_171th-m.OUT
04/28/2006 10:42 AM 57,752 Stress-pt_171th-t.OUT
04/28/2006 10:43 AM 16,295 Stress-pt_180max-b.OUT
04/28/2006 10:43 AM 16,295 Stress-pt_180max-m.OUT
04/28/2006 10:43 AM 16,214 Stress-pt_180max-t.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_180th-b.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_180th-m.OUT
04/28/2006 10:43 AM 57,752 Stress-pt_180th-t.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_18max-b.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_18max-m.OUT
04/28/2006 10:42 AM 16,210 Stress-pt_18max-t.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_18th-b.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_18th-m.OUT
04/28/2006 10:42 AM 57,752 Stress-pt_18th-t.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_27max-b.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_27max-m.OUT
04/28/2006 10:42 AM 16,210 Stress-pt_27max-t.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_27th-b.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_27th-m.OUT
04/28/2006 10:42 AM 57,752 Stress-pt_27th-t.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_36max-b.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_36max-m.OUT
04/28/2006 10:42 AM 16,210 Stress-pt_36max-t.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_36th-b.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_36th-m.OUT
04/28/2006 10:42 AM 57,752 Stress-pt_36th-t.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_45max-b.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_45max-m.OUT
04/28/2006 10:42 AM 16,210 Stress-pt_45max-t.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_45th-b.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_45th-m.OUT
04/28/2006 10:42 AM 57,752 Stress-pt_45th-t.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_54max-b.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_54max-m.OUT
04/28/2006 10:42 AM 16,210 Stress-pt_54max-t.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_54th-b.OUT
04/28/2006 10:43 AM 57,948 Stress-pt_54th-m.OUT
04/28/2006 10:42 AM 57,752 Stress-pt_54th-t.OUT
04/28/2006 10:43 AM 16,291 Stress-pt_63max-b.OUT

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04/28/2006  10:43 AM                16,291
Stress-pt_63max-m.OUT
04/28/2006  10:42 AM                16,210
Stress-pt_63max-t.OUT
04/28/2006  10:43 AM                57,948
Stress-pt_63th-b.OUT
04/28/2006  10:43 AM                57,948
Stress-pt_63th-m.OUT
04/28/2006  10:42 AM                57,752
Stress-pt_63th-t.OUT
04/28/2006  10:43 AM                16,291
Stress-pt_72max-b.OUT
04/28/2006  10:43 AM                16,291
Stress-pt_72max-m.OUT
04/28/2006  10:42 AM                16,210
Stress-pt_72max-t.OUT
04/28/2006  10:43 AM                57,948
Stress-pt_72th-b.OUT
04/28/2006  10:43 AM                57,948
Stress-pt_72th-m.OUT
04/28/2006  10:42 AM                57,752
Stress-pt_72th-t.OUT
04/28/2006  10:43 AM                16,291
Stress-pt_81max-b.OUT
04/28/2006  10:43 AM                16,291
Stress-pt_81max-m.OUT
04/28/2006  10:42 AM                16,210
Stress-pt_81max-t.OUT
04/28/2006  10:43 AM                57,948
Stress-pt_81th-b.OUT
04/28/2006  10:43 AM                57,948
Stress-pt_81th-m.OUT
04/28/2006  10:42 AM                57,752
Stress-pt_81th-t.OUT
04/28/2006  10:43 AM                16,291
Stress-pt_90max-b.OUT
04/28/2006  10:43 AM                16,291
Stress-pt_90max-m.OUT
04/28/2006  10:42 AM                16,210
Stress-pt_90max-t.OUT
04/28/2006  10:43 AM                57,948
Stress-pt_90th-b.OUT
04/28/2006  10:43 AM                57,948
Stress-pt_90th-m.OUT
04/28/2006  10:42 AM                57,752
Stress-pt_90th-t.OUT
04/28/2006  10:43 AM                16,291
Stress-pt_99max-b.OUT
04/28/2006  10:43 AM                16,291
Stress-pt_99max-m.OUT
04/28/2006  10:42 AM                16,210
Stress-pt_99max-t.OUT
04/28/2006  10:43 AM                57,948
Stress-pt_99th-b.OUT
04/28/2006  10:43 AM                57,948
Stress-pt_99th-m.OUT
04/28/2006  10:42 AM                57,752
Stress-pt_99th-t.OUT
04/28/2006  10:43 AM                16,291
Stress-pt_9max-b.OUT
04/28/2006  10:43 AM                16,291
Stress-pt_9max-m.OUT
04/28/2006  10:42 AM                16,210
Stress-pt_9max-t.OUT
04/28/2006  10:43 AM                58,076
Stress-pt_9th-b.OUT
04/28/2006  10:43 AM                58,076
Stress-pt_9th-m.OUT
04/28/2006  10:42 AM                57,880
Stress-pt_9th-t.OUT
10/31/2005  01:13 PM             3,825
Tank-Coordinates-AY.txt
05/25/2005  04:32 PM             2,512
Tank-Mesh1.txt
04/28/2006  10:21 AM               102
tank-out.out
02/25/2005  03:24 PM             5,406
Tank-Props-BEC-250.txt
04/28/2006  10:21 AM             4,692
Tank-th.out
12/22/2005  01:43 PM            10,035
temp.log
05/16/2005  04:40 PM            41,470
TH-266-Mean-Geo-V.txt
05/13/2005  11:57 AM            41,472
TH-266-Mean-Geo.txt
11/01/2005  01:19 PM               342
Waste-Reaction.txt
10/31/2005  01:01 PM             3,265
Waste-solid-AY.txt
04/24/2006  11:35 AM               240
Zero-Friction.log
             354 File(s)    643,379,243
bytes
               2 Dir(s)  154,590,904,320
bytes free
```

File Listing: Mu=0.3

```
 Volume in drive C is 600GB 2xRAID0
 Volume Serial Number is 8785-3B22

 Directory of C:\Users\Bruce\2008-000
PNNL\2008-006 J-Bolts\Mu-0.3-L

05/26/2006  01:06 PM    <DIR>          .
05/26/2006  01:06 PM    <DIR>          ..
04/25/2006  02:02 PM               100
All-Forces.txt
05/02/2006  10:58 AM           689,152
AY-2D-NL-BES-BEC J Bolt Forces Mu=0.3-
L.xls
05/02/2006  11:13 AM           903,168
AY-2D-NL-BES-BEC-J-Bolt-Contact-Mu=0.3-
L.xls
04/28/2006  10:17 AM            86,584
BEC-BES-Gravity-Dome-F-030-L.out
04/28/2006  10:16 AM             2,998
BES-BEC-Mu-030-L.BCS
04/28/2006  10:17 AM        55,508,992
BES-BEC-Mu-030-L.db
04/28/2006  10:15 AM        55,508,992
BES-BEC-Mu-030-L.dbb
04/28/2006  10:17 AM        12,386,304
BES-BEC-Mu-030-L.emat
04/28/2006  10:21 AM           159,695
BES-BEC-Mu-030-L.err
04/28/2006  10:17 AM       102,563,840
BES-BEC-Mu-030-L.esav
04/28/2006  10:17 AM        27,852,800
BES-BEC-Mu-030-L.full
04/28/2006  10:15 AM         1,605,361
BES-BEC-Mu-030-L.ldhi
04/28/2006  10:21 AM             7,754
BES-BEC-Mu-030-L.log
04/28/2006  10:17 AM             2,295
BES-BEC-Mu-030-L.mntr
04/28/2006  10:16 AM       102,563,840
BES-BEC-Mu-030-L.osav
```

```
04/28/2006  10:16 AM            1,411
BES-BEC-Mu-030-L.PVTS
04/28/2006  10:17 AM      103,546,880
BES-BEC-Mu-030-L.r001
04/28/2006  09:56 AM       35,782,656
BES-BEC-Mu-030-L.rdb
04/28/2006  10:17 AM      207,421,440
BES-BEC-Mu-030-L.rst
04/27/2006  05:28 PM               97
BES-BEC-Mu-030-L.stat
04/25/2006  04:44 PM               78
BES-BEC-Mu-030.log
04/28/2006  09:53 AM            5,788
Bolts-Friction.txt
06/09/2005  02:59 PM              262
Boundary.txt
04/25/2006  02:02 PM              195
Contact-AY.txt
12/01/2005  10:11 AM              586
Contact-Footing.txt
09/02/2005  10:28 AM              604
Contact-Insul.txt
04/25/2006  10:56 AM              655
Contact-J-Bolts.txt
09/09/2005  10:59 AM              608
Contact-Primary.txt
09/15/2005  12:50 PM              742
Contact-Soil.txt
09/06/2005  12:16 PM              630
Contact-Waste-AY.txt
01/03/2006  12:17 PM            1,616
Disp-J-Bolts.txt
09/22/2005  05:05 PM            8,608
Far-Soil.txt
04/27/2006  05:09 PM            1,988
file.bat
04/27/2006  05:09 PM              204
file.err
04/27/2006  05:09 PM            3,152
file.log
10/13/2005  07:54 AM              562
Fix-Soil.txt
04/06/2005  09:24 AM              894
Force-c.txt
04/28/2006  10:17 AM            4,996
Force-c_108amax.OUT
04/28/2006  10:17 AM           19,200
Force-c_108ath.OUT
04/28/2006  10:17 AM           14,716
Force-c_108max.OUT
04/28/2006  10:17 AM           41,040
Force-c_108th.OUT
04/28/2006  10:17 AM            4,996
Force-c_117amax.OUT
04/28/2006  10:17 AM           19,200
Force-c_117ath.OUT
04/28/2006  10:17 AM           14,716
Force-c_117max.OUT
04/28/2006  10:17 AM           41,040
Force-c_117th.OUT
04/28/2006  10:17 AM            4,996
Force-c_126amax.OUT
04/28/2006  10:17 AM           19,200
Force-c_126ath.OUT
04/28/2006  10:17 AM           14,716
Force-c_126max.OUT
04/28/2006  10:17 AM           41,040
Force-c_126th.OUT
04/28/2006  10:17 AM            4,996
Force-c_135amax.OUT
04/28/2006  10:17 AM           19,200
Force-c_135ath.OUT
04/28/2006  10:17 AM           14,716
Force-c_135max.OUT
04/28/2006  10:17 AM           41,040
Force-c_135th.OUT
04/28/2006  10:17 AM            4,996
Force-c_144amax.OUT
04/28/2006  10:17 AM           19,200
Force-c_144ath.OUT
04/28/2006  10:17 AM           14,716
Force-c_144max.OUT
04/28/2006  10:17 AM           41,040
Force-c_144th.OUT
04/28/2006  10:17 AM            4,996
Force-c_153amax.OUT
04/28/2006  10:17 AM           19,200
Force-c_153ath.OUT
04/28/2006  10:17 AM           14,716
Force-c_153max.OUT
04/28/2006  10:17 AM           41,040
Force-c_153th.OUT
04/28/2006  10:17 AM            4,996
Force-c_162amax.OUT
04/28/2006  10:17 AM           19,200
Force-c_162ath.OUT
04/28/2006  10:17 AM           14,716
Force-c_162max.OUT
04/28/2006  10:17 AM           41,040
Force-c_162th.OUT
04/28/2006  10:17 AM            4,996
Force-c_171amax.OUT
04/28/2006  10:17 AM           19,200
Force-c_171ath.OUT
04/28/2006  10:17 AM           14,716
Force-c_171max.OUT
04/28/2006  10:17 AM           41,040
Force-c_171th.OUT
04/28/2006  10:17 AM            4,996
Force-c_180amax.OUT
04/28/2006  10:17 AM           19,200
Force-c_180ath.OUT
04/28/2006  10:17 AM           14,716
Force-c_180max.OUT
04/28/2006  10:17 AM           41,040
Force-c_180th.OUT
04/28/2006  10:17 AM            4,996
Force-c_18amax.OUT
04/28/2006  10:17 AM           19,200
Force-c_18ath.OUT
04/28/2006  10:17 AM           14,716
Force-c_18max.OUT
04/28/2006  10:17 AM           41,040
Force-c_18th.OUT
04/28/2006  10:17 AM            4,996
Force-c_27amax.OUT
04/28/2006  10:17 AM           19,200
Force-c_27ath.OUT
04/28/2006  10:17 AM           14,716
Force-c_27max.OUT
04/28/2006  10:17 AM           41,040
Force-c_27th.OUT
04/28/2006  10:17 AM            4,996
Force-c_36amax.OUT
04/28/2006  10:17 AM           19,200
Force-c_36ath.OUT
04/28/2006  10:17 AM           14,716
Force-c_36max.OUT
04/28/2006  10:17 AM           41,040
Force-c_36th.OUT
```

```
04/28/2006  10:17 AM             4,996
Force-c_45amax.OUT
04/28/2006  10:17 AM            19,200
Force-c_45ath.OUT
04/28/2006  10:17 AM            14,716
Force-c_45max.OUT
04/28/2006  10:17 AM            41,040
Force-c_45th.OUT
04/28/2006  10:17 AM             4,996
Force-c_54amax.OUT
04/28/2006  10:17 AM            19,200
Force-c_54ath.OUT
04/28/2006  10:17 AM            14,716
Force-c_54max.OUT
04/28/2006  10:17 AM            41,040
Force-c_54th.OUT
04/28/2006  10:17 AM             4,996
Force-c_63amax.OUT
04/28/2006  10:17 AM            19,200
Force-c_63ath.OUT
04/28/2006  10:17 AM            14,716
Force-c_63max.OUT
04/28/2006  10:17 AM            41,040
Force-c_63th.OUT
04/28/2006  10:17 AM             4,996
Force-c_72amax.OUT
04/28/2006  10:17 AM            19,200
Force-c_72ath.OUT
04/28/2006  10:17 AM            14,716
Force-c_72max.OUT
04/28/2006  10:17 AM            41,040
Force-c_72th.OUT
04/28/2006  10:17 AM             4,996
Force-c_81amax.OUT
04/28/2006  10:17 AM            19,200
Force-c_81ath.OUT
04/28/2006  10:17 AM            14,716
Force-c_81max.OUT
04/28/2006  10:17 AM            41,040
Force-c_81th.OUT
04/28/2006  10:17 AM             4,996
Force-c_90amax.OUT
04/28/2006  10:17 AM            19,200
Force-c_90ath.OUT
04/28/2006  10:17 AM            14,716
Force-c_90max.OUT
04/28/2006  10:17 AM            41,040
Force-c_90th.OUT
04/28/2006  10:17 AM             4,996
Force-c_99amax.OUT
04/28/2006  10:17 AM            19,200
Force-c_99ath.OUT
04/28/2006  10:17 AM            14,716
Force-c_99max.OUT
04/28/2006  10:17 AM            41,040
Force-c_99th.OUT
04/28/2006  10:17 AM             4,996
Force-c_9amax.OUT
04/28/2006  10:17 AM            19,328
Force-c_9ath.OUT
04/28/2006  10:17 AM            14,716
Force-c_9max.OUT
04/28/2006  10:17 AM            41,168
Force-c_9th.OUT
04/28/2006  10:19 AM           136,192
force-jb.xls
04/28/2006  10:18 AM            17,262
Force-jb_r10-th.OUT
04/28/2006  10:18 AM             5,239
Force-jb_r10_max.OUT
04/28/2006  10:18 AM            17,262
Force-jb_r11-th.OUT
04/28/2006  10:18 AM             5,239
Force-jb_r11_max.OUT
04/28/2006  10:17 AM            17,390
Force-jb_r2-th.OUT
04/28/2006  10:17 AM             5,239
Force-jb_r2_max.OUT
04/28/2006  10:17 AM            17,262
Force-jb_r3-th.OUT
04/28/2006  10:17 AM             5,239
Force-jb_r3_max.OUT
04/28/2006  10:17 AM            17,262
Force-jb_r4-th.OUT
04/28/2006  10:17 AM             5,239
Force-jb_r4_max.OUT
04/28/2006  10:17 AM            17,262
Force-jb_r5-th.OUT
04/28/2006  10:17 AM             5,239
Force-jb_r5_max.OUT
04/28/2006  10:17 AM            17,262
Force-jb_r6-th.OUT
04/28/2006  10:17 AM             5,239
Force-jb_r6_max.OUT
04/28/2006  10:17 AM            17,262
Force-jb_r7-th.OUT
04/28/2006  10:17 AM             5,239
Force-jb_r7_max.OUT
04/28/2006  10:17 AM            17,262
Force-jb_r8-th.OUT
04/28/2006  10:17 AM             5,239
Force-jb_r8_max.OUT
04/28/2006  10:18 AM            17,262
Force-jb_r9-th.OUT
04/28/2006  10:18 AM             5,239
Force-jb_r9_max.OUT
06/20/2005  11:53 AM               661
Force-j_bolt.txt
09/01/2005  11:27 AM             1,664
Insulate.txt
10/13/2005  09:28 AM             4,031
interface-gap1.txt
09/09/2005  10:34 AM             2,616
interface1.txt
04/28/2006  10:19 AM           101,376 J-
Bolt-Contact_0-90.xls
04/28/2006  10:20 AM           100,864 J-
Bolt-Contact_99-180.xls
04/28/2006  10:17 AM             3,781 J-
Bolt-Cont_108max.OUT
04/28/2006  10:17 AM             9,036 J-
Bolt-Cont_108th.OUT
04/28/2006  10:17 AM             3,781 J-
Bolt-Cont_117max.OUT
04/28/2006  10:17 AM             9,036 J-
Bolt-Cont_117th.OUT
04/28/2006  10:17 AM             3,781 J-
Bolt-Cont_126max.OUT
04/28/2006  10:17 AM             9,036 J-
Bolt-Cont_126th.OUT
04/28/2006  10:17 AM             3,781 J-
Bolt-Cont_135max.OUT
04/28/2006  10:17 AM             9,036 J-
Bolt-Cont_135th.OUT
04/28/2006  10:17 AM             3,781 J-
Bolt-Cont_144max.OUT
04/28/2006  10:17 AM             9,036 J-
Bolt-Cont_144th.OUT
04/28/2006  10:17 AM             3,781 J-
Bolt-Cont_153max.OUT
```

04/28/2006 10:17 AM	9,036 J-	Bolt-Cont_153th.OUT
04/28/2006 10:17 AM	3,781 J-	Bolt-Cont_162max.OUT
04/28/2006 10:17 AM	9,036 J-	Bolt-Cont_162th.OUT
04/28/2006 10:17 AM	3,781 J-	Bolt-Cont_171max.OUT
04/28/2006 10:17 AM	9,036 J-	Bolt-Cont_171th.OUT
04/28/2006 10:17 AM	3,781 J-	Bolt-Cont_180max.OUT
04/28/2006 10:17 AM	9,036 J-	Bolt-Cont_180th.OUT
04/28/2006 10:17 AM	3,781 J-	Bolt-Cont_18max.OUT
04/28/2006 10:17 AM	9,036 J-	Bolt-Cont_18th.OUT
04/28/2006 10:17 AM	3,781 J-	Bolt-Cont_27max.OUT
04/28/2006 10:17 AM	9,036 J-	Bolt-Cont_27th.OUT
04/28/2006 10:17 AM	3,781 J-	Bolt-Cont_36max.OUT
04/28/2006 10:17 AM	9,036 J-	Bolt-Cont_36th.OUT
04/28/2006 10:17 AM	3,781 J-	Bolt-Cont_45max.OUT
04/28/2006 10:17 AM	9,036 J-	Bolt-Cont_45th.OUT
04/28/2006 10:17 AM	3,781 J-	Bolt-Cont_54max.OUT
04/28/2006 10:17 AM	9,036 J-	Bolt-Cont_54th.OUT
04/28/2006 10:17 AM	3,781 J-	Bolt-Cont_63max.OUT
04/28/2006 10:17 AM	9,036 J-	Bolt-Cont_63th.OUT
04/28/2006 10:17 AM	3,781 J-	Bolt-Cont_72max.OUT
04/28/2006 10:17 AM	9,036 J-	Bolt-Cont_72th.OUT
04/28/2006 10:17 AM	3,781 J-	Bolt-Cont_81max.OUT
04/28/2006 10:17 AM	9,036 J-	Bolt-Cont_81th.OUT
04/28/2006 10:17 AM	3,781 J-	Bolt-Cont_90max.OUT
04/28/2006 10:17 AM	9,036 J-	Bolt-Cont_90th.OUT
04/28/2006 10:17 AM	3,781 J-	Bolt-Cont_99max.OUT
04/28/2006 10:17 AM	9,036 J-	Bolt-Cont_99th.OUT
04/28/2006 10:17 AM	3,781 J-	Bolt-Cont_9max.OUT
04/28/2006 10:17 AM	9,164 J-	Bolt-Cont_9th.OUT
06/01/2005 02:17 PM	1,708	Liner.txt
05/26/2006 01:06 PM	0	lis.txt
05/02/2005 03:19 PM	667	live_load.txt
11/11/2005 11:38 AM	6,185	Near-Soil-1.txt
04/20/2005 02:14 PM	508	outer-spar.txt
10/31/2005 01:18 PM	5,549	Primary-Props-AY.txt

09/27/2005 04:52 PM	1,538	Primary.txt
04/28/2006 09:56 AM	383,577	QA.out
10/31/2005 11:31 AM	1,108	RS_FREQ.txt
04/27/2006 05:30 PM	3,240,443	Run-Tank-Out.out
04/28/2006 09:19 AM	1,900	Run-Tank.txt
04/28/2006 09:19 AM	0	scratch.hlp
02/11/2005 02:22 PM	1,053	Slave.txt
11/11/2005 11:36 AM	4,989	Soil-Prop-Mean-Geo.txt
04/27/2006 02:16 PM	1,924	Solve-Gravity-BES.txt
10/31/2005 12:02 PM	3,363	spectra-conc-0.txt
10/14/2005 12:18 PM	2,061	spectra-concrete.txt
10/31/2005 11:17 AM	3,551	spectra-primary-180.txt
09/06/2005 07:49 AM	1,287	spectra-soil.txt
06/20/2005 10:04 AM	647	spectra-wall.txt
06/20/2005 09:52 AM	679	spectra-waste.txt
01/05/2006 04:12 PM	566	strain-compb-p.txt
01/05/2006 04:11 PM	566	strain-compb.txt
01/05/2006 04:13 PM	566	strain-compm-p.txt
09/02/2005 09:51 AM	705	strain-compm.txt
01/05/2006 04:14 PM	578	strain-compt-p.txt
09/02/2005 09:50 AM	720	strain-compt.txt
01/06/2006 10:07 AM	728	Strain-Liner-floor.txt
01/05/2006 04:14 PM	550	Strain-Liner-p.txt
01/06/2006 03:45 PM	823	Strain-Liner-wall.txt
09/02/2005 09:52 AM	544	Strain-Liner.txt
01/06/2006 03:46 PM	274	Strain-Primary.txt
01/06/2006 03:48 PM	246	Strain.txt
01/06/2006 03:41 PM	554	stress-compb-p.txt
09/08/2005 11:18 AM	692	stress-compb.txt
01/06/2006 03:40 PM	554	stress-compm-p.txt
11/01/2005 11:46 AM	702	stress-compm.txt
01/06/2006 03:40 PM	554	stress-compt-p.txt
09/08/2005 10:20 AM	692	stress-compt.txt
04/13/2005 08:38 AM	205	Stress-Primary.txt
04/28/2006 10:17 AM	16,291	Stress-pt_108max-b.OUT

```
04/28/2006  10:17 AM              16,291
Stress-pt_108max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_108max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_108th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_108th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_108th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_117max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_117max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_117max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_117th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_117th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_117th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_126max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_126max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_126max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_126th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_126th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_126th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_135max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_135max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_135max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_135th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_135th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_135th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_144max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_144max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_144max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_144th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_144th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_144th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_153max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_153max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_153max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_153th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_153th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_153th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_162max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_162max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_162max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_162th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_162th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_162th-t.OUT
04/28/2006  10:17 AM              16,295
Stress-pt_171max-b.OUT
04/28/2006  10:17 AM              16,295
Stress-pt_171max-m.OUT
04/28/2006  10:17 AM              16,214
Stress-pt_171max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_171th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_171th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_171th-t.OUT
04/28/2006  10:17 AM              16,295
Stress-pt_180max-b.OUT
04/28/2006  10:17 AM              16,295
Stress-pt_180max-m.OUT
04/28/2006  10:17 AM              16,214
Stress-pt_180max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_180th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_180th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_180th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_18max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_18max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_18max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_18th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_18th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_18th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_27max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_27max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_27max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_27th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_27th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_27th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_36max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_36max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_36max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_36th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_36th-m.OUT
```

```
04/28/2006  10:17 AM              48,182
Stress-pt_36th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_45max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_45max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_45max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_45th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_45th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_45th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_54max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_54max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_54max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_54th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_54th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_54th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_63max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_63max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_63max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_63th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_63th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_63th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_72max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_72max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_72max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_72th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_72th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_72th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_81max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_81max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_81max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_81th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_81th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_81th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_90max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_90max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_90max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_90th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_90th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_90th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_99max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_99max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_99max-t.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_99th-b.OUT
04/28/2006  10:17 AM              48,378
Stress-pt_99th-m.OUT
04/28/2006  10:17 AM              48,182
Stress-pt_99th-t.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_9max-b.OUT
04/28/2006  10:17 AM              16,291
Stress-pt_9max-m.OUT
04/28/2006  10:17 AM              16,210
Stress-pt_9max-t.OUT
04/28/2006  10:17 AM              48,506
Stress-pt_9th-b.OUT
04/28/2006  10:17 AM              48,506
Stress-pt_9th-m.OUT
04/28/2006  10:17 AM              48,310
Stress-pt_9th-t.OUT
10/31/2005  01:13 PM               3,825
Tank-Coordinates-AY.txt
05/25/2005  04:32 PM               2,512
Tank-Mesh1.txt
04/28/2006  09:55 AM                 102
tank-out.out
02/25/2005  03:24 PM               5,406
Tank-Props-BEC-250.txt
04/28/2006  09:56 AM               4,994
Tank-th.out
12/22/2005  01:43 PM              10,035
temp.log
05/16/2005  04:40 PM              41,470
TH-266-Mean-Geo-V.txt
05/13/2005  11:57 AM              41,472
TH-266-Mean-Geo.txt
11/01/2005  01:19 PM                 342
Waste-Reaction.txt
10/31/2005  01:01 PM               3,265
Waste-solid-AY.txt
04/24/2006  11:35 AM                 240
Zero-Friction.log
             355 File(s)    716,712,064
bytes
               2 Dir(s)  154,590,879,744
bytes free
```

File Listing: Mu=0.4

```
 Volume in drive C is 600GB 2xRAID0
 Volume Serial Number is 8785-3B22

 Directory of C:\Users\Bruce\2008-000
PNNL\2008-006 J-Bolts\Mu-0.4-L

05/26/2006  01:06 PM    <DIR>          .
05/26/2006  01:06 PM    <DIR>          ..
04/25/2006  02:02 PM                 100
All-Forces.txt
05/02/2006  11:15 AM           3,174,912
AY-2D-NL-BES-BEC Conc Tank Demand Gravity
Mu=0.4-L.xls
```

```
04/28/2006  09:49 AM           685,568
AY-2D-NL-BES-BEC J Bolt Forces Mu=0.4-
L.xls
05/03/2006  08:06 AM         8,399,872
AY-2D-NL-BES-BEC Pri Tank Stress Gravity
Mu=0.4-L.xls
05/02/2006  11:11 AM           903,168
AY-2D-NL-BES-BEC-J-Bolt-Contact-Mu=0.4-
L.xls
04/28/2006  08:52 AM            86,035
BEC-BES-Gravity-Dome-F-040-L.out
04/28/2006  08:52 AM             2,998
BES-BEC-Mu-040-L.BCS
04/28/2006  08:52 AM        55,508,992
BES-BEC-Mu-040-L.db
04/28/2006  08:50 AM        55,508,992
BES-BEC-Mu-040-L.dbb
04/28/2006  08:52 AM        12,386,304
BES-BEC-Mu-040-L.emat
05/08/2006  01:49 PM           120,076
BES-BEC-Mu-040-L.err
04/28/2006  08:52 AM       102,563,840
BES-BEC-Mu-040-L.esav
04/28/2006  08:52 AM        27,852,800
BES-BEC-Mu-040-L.full
04/28/2006  08:50 AM         1,605,361
BES-BEC-Mu-040-L.ldhi
05/08/2006  01:49 PM            15,924
BES-BEC-Mu-040-L.log
04/28/2006  08:52 AM             2,295
BES-BEC-Mu-040-L.mntr
04/28/2006  08:51 AM       102,563,840
BES-BEC-Mu-040-L.osav
04/28/2006  08:51 AM             1,411
BES-BEC-Mu-040-L.PVTS
04/28/2006  08:52 AM       103,546,880
BES-BEC-Mu-040-L.r001
04/28/2006  08:31 AM        35,782,656
BES-BEC-Mu-040-L.rdb
04/28/2006  08:52 AM       207,421,440
BES-BEC-Mu-040-L.rst
04/27/2006  05:07 PM                97
BES-BEC-Mu-040-L.stat
04/25/2006  04:23 PM                78
BES-BEC-Mu-040.log
04/28/2006  08:29 AM             5,788
Bolts-Friction.txt
06/09/2005  02:59 PM               262
Boundary.txt
04/25/2006  02:02 PM               195
Contact-AY.txt
12/01/2005  10:11 AM               586
Contact-Footing.txt
09/02/2005  10:28 AM               604
Contact-Insul.txt
04/25/2006  10:56 AM               655
Contact-J-Bolts.txt
09/09/2005  10:59 AM               608
Contact-Primary.txt
09/15/2005  12:50 PM               742
Contact-Soil.txt
09/06/2005  12:16 PM               630
Contact-Waste-AY.txt
01/03/2006  12:17 PM             1,616
Disp-J-Bolts.txt
09/22/2005  05:05 PM             8,608
Far-Soil.txt
04/27/2006  04:48 PM             1,988
file.bat
04/27/2006  04:48 PM               136
file.err
04/27/2006  04:48 PM             3,152
file.log
10/13/2005  07:54 AM               562
Fix-Soil.txt
04/06/2005  09:24 AM               894
Force-c.txt
04/28/2006  08:52 AM             4,996
Force-c_108amax.OUT
04/28/2006  08:52 AM            19,200
Force-c_108ath.OUT
04/28/2006  08:52 AM            14,716
Force-c_108max.OUT
04/28/2006  08:52 AM            41,040
Force-c_108th.OUT
04/28/2006  08:52 AM             4,996
Force-c_117amax.OUT
04/28/2006  08:52 AM            19,200
Force-c_117ath.OUT
04/28/2006  08:52 AM            14,716
Force-c_117max.OUT
04/28/2006  08:52 AM            41,040
Force-c_117th.OUT
04/28/2006  08:52 AM             4,996
Force-c_126amax.OUT
04/28/2006  08:52 AM            19,200
Force-c_126ath.OUT
04/28/2006  08:52 AM            14,716
Force-c_126max.OUT
04/28/2006  08:52 AM            41,040
Force-c_126th.OUT
04/28/2006  08:52 AM             4,996
Force-c_135amax.OUT
04/28/2006  08:52 AM            19,200
Force-c_135ath.OUT
04/28/2006  08:52 AM            14,716
Force-c_135max.OUT
04/28/2006  08:52 AM            41,040
Force-c_135th.OUT
04/28/2006  08:52 AM             4,996
Force-c_144amax.OUT
04/28/2006  08:52 AM            19,200
Force-c_144ath.OUT
04/28/2006  08:52 AM            14,716
Force-c_144max.OUT
04/28/2006  08:52 AM            41,040
Force-c_144th.OUT
04/28/2006  08:52 AM             4,996
Force-c_153amax.OUT
04/28/2006  08:52 AM            19,200
Force-c_153ath.OUT
04/28/2006  08:52 AM            14,716
Force-c_153max.OUT
04/28/2006  08:52 AM            41,040
Force-c_153th.OUT
04/28/2006  08:52 AM             4,996
Force-c_162amax.OUT
04/28/2006  08:52 AM            19,200
Force-c_162ath.OUT
04/28/2006  08:52 AM            14,716
Force-c_162max.OUT
04/28/2006  08:52 AM            41,040
Force-c_162th.OUT
04/28/2006  08:52 AM             4,996
Force-c_171amax.OUT
04/28/2006  08:52 AM            19,200
Force-c_171ath.OUT
04/28/2006  08:52 AM            14,716
Force-c_171max.OUT
04/28/2006  08:52 AM            41,040
Force-c_171th.OUT
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04/28/2006  08:52 AM              4,996
Force-c_180amax.OUT
04/28/2006  08:52 AM             19,200
Force-c_180ath.OUT
04/28/2006  08:52 AM             14,716
Force-c_180max.OUT
04/28/2006  08:52 AM             41,040
Force-c_180th.OUT
04/28/2006  08:52 AM              4,996
Force-c_18amax.OUT
04/28/2006  08:52 AM             19,200
Force-c_18ath.OUT
04/28/2006  08:52 AM             14,716
Force-c_18max.OUT
04/28/2006  08:52 AM             41,040
Force-c_18th.OUT
04/28/2006  08:52 AM              4,996
Force-c_27amax.OUT
04/28/2006  08:52 AM             19,200
Force-c_27ath.OUT
04/28/2006  08:52 AM             14,716
Force-c_27max.OUT
04/28/2006  08:52 AM             41,040
Force-c_27th.OUT
04/28/2006  08:52 AM              4,996
Force-c_36amax.OUT
04/28/2006  08:52 AM             19,200
Force-c_36ath.OUT
04/28/2006  08:52 AM             14,716
Force-c_36max.OUT
04/28/2006  08:52 AM             41,040
Force-c_36th.OUT
04/28/2006  08:52 AM              4,996
Force-c_45amax.OUT
04/28/2006  08:52 AM             19,200
Force-c_45ath.OUT
04/28/2006  08:52 AM             14,716
Force-c_45max.OUT
04/28/2006  08:52 AM             41,040
Force-c_45th.OUT
04/28/2006  08:52 AM              4,996
Force-c_54amax.OUT
04/28/2006  08:52 AM             19,200
Force-c_54ath.OUT
04/28/2006  08:52 AM             14,716
Force-c_54max.OUT
04/28/2006  08:52 AM             41,040
Force-c_54th.OUT
04/28/2006  08:52 AM              4,996
Force-c_63amax.OUT
04/28/2006  08:52 AM             19,200
Force-c_63ath.OUT
04/28/2006  08:52 AM             14,716
Force-c_63max.OUT
04/28/2006  08:52 AM             41,040
Force-c_63th.OUT
04/28/2006  08:52 AM              4,996
Force-c_72amax.OUT
04/28/2006  08:52 AM             19,200
Force-c_72ath.OUT
04/28/2006  08:52 AM             14,716
Force-c_72max.OUT
04/28/2006  08:52 AM             41,040
Force-c_72th.OUT
04/28/2006  08:52 AM              4,996
Force-c_81amax.OUT
04/28/2006  08:52 AM             19,200
Force-c_81ath.OUT
04/28/2006  08:52 AM             14,716
Force-c_81max.OUT
04/28/2006  08:52 AM             41,040
Force-c_81th.OUT
04/28/2006  08:52 AM              4,996
Force-c_90amax.OUT
04/28/2006  08:52 AM             19,200
Force-c_90ath.OUT
04/28/2006  08:52 AM             14,716
Force-c_90max.OUT
04/28/2006  08:52 AM             41,040
Force-c_90th.OUT
04/28/2006  08:52 AM              4,996
Force-c_99amax.OUT
04/28/2006  08:52 AM             19,200
Force-c_99ath.OUT
04/28/2006  08:52 AM             14,716
Force-c_99max.OUT
04/28/2006  08:52 AM             41,040
Force-c_99th.OUT
04/28/2006  08:52 AM              4,996
Force-c_9amax.OUT
04/28/2006  08:52 AM             19,328
Force-c_9ath.OUT
04/28/2006  08:52 AM             14,716
Force-c_9max.OUT
04/28/2006  08:52 AM             41,168
Force-c_9th.OUT
04/28/2006  09:04 AM            136,192
force-jb.xls
04/28/2006  08:53 AM             17,262
Force-jb_r10-th.OUT
04/28/2006  08:53 AM              5,239
Force-jb_r10_max.OUT
04/28/2006  08:53 AM             17,262
Force-jb_r11-th.OUT
04/28/2006  08:53 AM              5,239
Force-jb_r11_max.OUT
04/28/2006  08:53 AM             17,390
Force-jb_r2-th.OUT
04/28/2006  08:53 AM              5,239
Force-jb_r2_max.OUT
04/28/2006  08:53 AM             17,262
Force-jb_r3-th.OUT
04/28/2006  08:53 AM              5,239
Force-jb_r3_max.OUT
04/28/2006  08:53 AM             17,262
Force-jb_r4-th.OUT
04/28/2006  08:53 AM              5,239
Force-jb_r4_max.OUT
04/28/2006  08:53 AM             17,262
Force-jb_r5-th.OUT
04/28/2006  08:53 AM              5,239
Force-jb_r5_max.OUT
04/28/2006  08:53 AM             17,262
Force-jb_r6-th.OUT
04/28/2006  08:53 AM              5,239
Force-jb_r6_max.OUT
04/28/2006  08:53 AM             17,262
Force-jb_r7-th.OUT
04/28/2006  08:53 AM              5,239
Force-jb_r7_max.OUT
04/28/2006  08:53 AM             17,262
Force-jb_r8-th.OUT
04/28/2006  08:53 AM              5,239
Force-jb_r8_max.OUT
04/28/2006  08:53 AM             17,262
Force-jb_r9-th.OUT
04/28/2006  08:53 AM              5,239
Force-jb_r9_max.OUT
06/20/2005  11:53 AM                661
Force-j_bolt.txt
```

04/28/2006 12:01 PM	442,880	import_0-90.xls
04/28/2006 12:01 PM	443,392	import_99-180.xls
09/01/2005 11:27 AM	1,664	Insulate.txt
10/13/2005 09:28 AM	4,031	interface-gap1.txt
09/09/2005 10:34 AM	2,616	interface1.txt
04/28/2006 09:00 AM	101,376 J-	Bolt-Contact_0-90.xls
04/28/2006 09:00 AM	101,376 J-	Bolt-Contact_99-180.xls
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_108max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_108th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_117max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_117th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_126max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_126th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_135max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_135th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_144max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_144th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_153max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_153th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_162max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_162th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_171max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_171th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_180max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_180th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_18max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_18th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_27max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_27th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_36max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_36th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_45max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_45th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_54max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_54th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_63max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_63th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_72max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_72th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_81max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_81th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_90max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_90th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_99max.OUT
04/28/2006 08:52 AM	9,036 J-	Bolt-Cont_99th.OUT
04/28/2006 08:52 AM	3,781 J-	Bolt-Cont_9max.OUT
04/28/2006 08:52 AM	9,164 J-	Bolt-Cont_9th.OUT
06/01/2005 02:17 PM	1,708	Liner.txt
05/26/2006 01:06 PM	0	lis.txt
05/02/2005 03:19 PM	667	live_load.txt
11/11/2005 11:38 AM	6,185	Near-Soil-1.txt
04/20/2005 02:14 PM	508	outer-spar.txt
10/31/2005 01:18 PM	5,549	Primary-Props-AY.txt
09/27/2005 04:52 PM	1,538	Primary.txt
04/28/2006 08:31 AM	384,006	QA.out
10/31/2005 11:31 AM	1,108	RS_FREQ.txt
04/27/2006 05:09 PM	3,240,443	Run-Tank-Out.out
04/28/2006 08:30 AM	1,900	Run-Tank.txt
04/28/2006 08:30 AM	0	scratch.hlp
02/11/2005 02:22 PM	1,053	Slave.txt
11/11/2005 11:36 AM	4,989	Soil-Prop-Mean-Geo.txt
04/27/2006 02:16 PM	1,924	Solve-Gravity-BES.txt
10/31/2005 12:02 PM	3,363	spectra-conc-0.txt
10/14/2005 12:18 PM	2,061	spectra-concrete.txt
10/31/2005 11:17 AM	3,551	spectra-primary-180.txt
09/06/2005 07:49 AM	1,287	spectra-soil.txt
06/20/2005 10:04 AM	647	spectra-wall.txt
06/20/2005 09:52 AM	679	spectra-waste.txt
04/28/2006 01:34 PM	348,672	str-primary_0-90b.xls
04/28/2006 01:34 PM	349,184	str-primary_0-90m.xls

04/28/2006 01:34 PM	347,136	str-primary_0-90t.xls
04/28/2006 01:49 PM	349,184	str-primary_99-180b.xls
04/28/2006 01:50 PM	349,696	str-primary_99-180m.xls
04/28/2006 01:50 PM	347,648	str-primary_99-180t.xls
01/05/2006 04:12 PM	566	strain-compb-p.txt
01/05/2006 04:11 PM	566	strain-compb.txt
01/05/2006 04:13 PM	566	strain-compm-p.txt
09/02/2005 09:51 AM	705	strain-compm.txt
01/05/2006 04:14 PM	578	strain-compt-p.txt
09/02/2005 09:50 AM	720	strain-compt.txt
01/06/2006 10:07 AM	728	Strain-Liner-floor.txt
01/05/2006 04:14 PM	550	Strain-Liner-p.txt
01/06/2006 03:45 PM	823	Strain-Liner-wall.txt
09/02/2005 09:52 AM	544	Strain-Liner.txt
01/06/2006 03:46 PM	274	Strain-Primary.txt
01/06/2006 03:48 PM	246	Strain.txt
01/06/2006 03:41 PM	554	stress-compb-p.txt
09/08/2005 11:18 AM	692	stress-compb.txt
01/06/2006 03:40 PM	554	stress-compm-p.txt
11/01/2005 11:46 AM	702	stress-compm.txt
01/06/2006 03:40 PM	554	stress-compt-p.txt
09/08/2005 10:20 AM	692	stress-compt.txt
04/13/2005 08:38 AM	205	Stress-Primary.txt
04/28/2006 08:52 AM	16,291	Stress-pt_108max-b.OUT
04/28/2006 08:52 AM	16,291	Stress-pt_108max-m.OUT
04/28/2006 08:52 AM	16,210	Stress-pt_108max-t.OUT
04/28/2006 08:52 AM	48,378	Stress-pt_108th-b.OUT
04/28/2006 08:52 AM	48,378	Stress-pt_108th-m.OUT
04/28/2006 08:52 AM	48,182	Stress-pt_108th-t.OUT
04/28/2006 08:52 AM	16,291	Stress-pt_117max-b.OUT
04/28/2006 08:52 AM	16,291	Stress-pt_117max-m.OUT
04/28/2006 08:52 AM	16,210	Stress-pt_117max-t.OUT
04/28/2006 08:52 AM	48,378	Stress-pt_117th-b.OUT
04/28/2006 08:52 AM	48,378	Stress-pt_117th-m.OUT
04/28/2006 08:52 AM	48,182	Stress-pt_117th-t.OUT
04/28/2006 08:52 AM	16,291	Stress-pt_126max-b.OUT
04/28/2006 08:52 AM	16,291	Stress-pt_126max-m.OUT
04/28/2006 08:52 AM	16,210	Stress-pt_126max-t.OUT
04/28/2006 08:52 AM	48,378	Stress-pt_126th-b.OUT
04/28/2006 08:52 AM	48,378	Stress-pt_126th-m.OUT
04/28/2006 08:52 AM	48,182	Stress-pt_126th-t.OUT
04/28/2006 08:52 AM	16,291	Stress-pt_135max-b.OUT
04/28/2006 08:52 AM	16,291	Stress-pt_135max-m.OUT
04/28/2006 08:52 AM	16,210	Stress-pt_135max-t.OUT
04/28/2006 08:52 AM	48,378	Stress-pt_135th-b.OUT
04/28/2006 08:52 AM	48,378	Stress-pt_135th-m.OUT
04/28/2006 08:52 AM	48,182	Stress-pt_135th-t.OUT
04/28/2006 08:52 AM	16,291	Stress-pt_144max-b.OUT
04/28/2006 08:52 AM	16,291	Stress-pt_144max-m.OUT
04/28/2006 08:52 AM	16,210	Stress-pt_144max-t.OUT
04/28/2006 08:52 AM	48,378	Stress-pt_144th-b.OUT
04/28/2006 08:52 AM	48,378	Stress-pt_144th-m.OUT
04/28/2006 08:52 AM	48,182	Stress-pt_144th-t.OUT
04/28/2006 08:52 AM	16,291	Stress-pt_153max-b.OUT
04/28/2006 08:52 AM	16,291	Stress-pt_153max-m.OUT
04/28/2006 08:52 AM	16,210	Stress-pt_153max-t.OUT
04/28/2006 08:52 AM	48,378	Stress-pt_153th-b.OUT
04/28/2006 08:52 AM	48,378	Stress-pt_153th-m.OUT
04/28/2006 08:52 AM	48,182	Stress-pt_153th-t.OUT
04/28/2006 08:52 AM	16,291	Stress-pt_162max-b.OUT
04/28/2006 08:52 AM	16,291	Stress-pt_162max-m.OUT
04/28/2006 08:52 AM	16,210	Stress-pt_162max-t.OUT
04/28/2006 08:53 AM	48,378	Stress-pt_162th-b.OUT
04/28/2006 08:52 AM	48,378	Stress-pt_162th-m.OUT
04/28/2006 08:52 AM	48,182	Stress-pt_162th-t.OUT
04/28/2006 08:53 AM	16,295	Stress-pt_171max-b.OUT
04/28/2006 08:52 AM	16,295	Stress-pt_171max-m.OUT
04/28/2006 08:52 AM	16,214	Stress-pt_171max-t.OUT
04/28/2006 08:53 AM	48,378	Stress-pt_171th-b.OUT
04/28/2006 08:52 AM	48,378	Stress-pt_171th-m.OUT

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04/28/2006  08:52 AM            48,182
Stress-pt_171th-t.OUT
04/28/2006  08:53 AM            16,295
Stress-pt_180max-b.OUT
04/28/2006  08:52 AM            16,295
Stress-pt_180max-m.OUT
04/28/2006  08:52 AM            16,214
Stress-pt_180max-t.OUT
04/28/2006  08:53 AM            48,378
Stress-pt_180th-b.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_180th-m.OUT
04/28/2006  08:52 AM            48,182
Stress-pt_180th-t.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_18max-b.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_18max-m.OUT
04/28/2006  08:52 AM            16,210
Stress-pt_18max-t.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_18th-b.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_18th-m.OUT
04/28/2006  08:52 AM            48,182
Stress-pt_18th-t.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_27max-b.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_27max-m.OUT
04/28/2006  08:52 AM            16,210
Stress-pt_27max-t.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_27th-b.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_27th-m.OUT
04/28/2006  08:52 AM            48,182
Stress-pt_27th-t.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_36max-b.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_36max-m.OUT
04/28/2006  08:52 AM            16,210
Stress-pt_36max-t.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_36th-b.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_36th-m.OUT
04/28/2006  08:52 AM            48,182
Stress-pt_36th-t.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_45max-b.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_45max-m.OUT
04/28/2006  08:52 AM            16,210
Stress-pt_45max-t.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_45th-b.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_45th-m.OUT
04/28/2006  08:52 AM            48,182
Stress-pt_45th-t.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_54max-b.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_54max-m.OUT
04/28/2006  08:52 AM            16,210
Stress-pt_54max-t.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_54th-b.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_54th-m.OUT
04/28/2006  08:52 AM            48,182
Stress-pt_54th-t.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_63max-b.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_63max-m.OUT
04/28/2006  08:52 AM            16,210
Stress-pt_63max-t.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_63th-b.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_63th-m.OUT
04/28/2006  08:52 AM            48,182
Stress-pt_63th-t.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_72max-b.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_72max-m.OUT
04/28/2006  08:52 AM            16,210
Stress-pt_72max-t.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_72th-b.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_72th-m.OUT
04/28/2006  08:52 AM            48,182
Stress-pt_72th-t.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_81max-b.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_81max-m.OUT
04/28/2006  08:52 AM            16,210
Stress-pt_81max-t.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_81th-b.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_81th-m.OUT
04/28/2006  08:52 AM            48,182
Stress-pt_81th-t.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_90max-b.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_90max-m.OUT
04/28/2006  08:52 AM            16,210
Stress-pt_90max-t.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_90th-b.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_90th-m.OUT
04/28/2006  08:52 AM            48,182
Stress-pt_90th-t.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_99max-b.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_99max-m.OUT
04/28/2006  08:52 AM            16,210
Stress-pt_99max-t.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_99th-b.OUT
04/28/2006  08:52 AM            48,378
Stress-pt_99th-m.OUT
04/28/2006  08:52 AM            48,182
Stress-pt_99th-t.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_9max-b.OUT
04/28/2006  08:52 AM            16,291
Stress-pt_9max-m.OUT
04/28/2006  08:52 AM            16,210
Stress-pt_9max-t.OUT
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04/28/2006  08:52 AM            48,506
Stress-pt_9th-b.OUT
04/28/2006  08:52 AM            48,506
Stress-pt_9th-m.OUT
04/28/2006  08:52 AM            48,310
Stress-pt_9th-t.OUT
10/31/2005  01:13 PM             3,825
Tank-Coordinates-AY.txt
05/25/2005  04:32 PM             2,512
Tank-Mesh1.txt
04/28/2006  08:30 AM               102
tank-out.out
02/25/2005  03:24 PM             5,406
Tank-Props-BEC-250.txt
04/28/2006  08:31 AM             4,843
Tank-th.out
12/22/2005  01:43 PM            10,035
temp.log
05/16/2005  04:40 PM            41,470
TH-266-Mean-Geo-V.txt
05/13/2005  11:57 AM            41,472
TH-266-Mean-Geo.txt
11/01/2005  01:19 PM               342
Waste-Reaction.txt
10/31/2005  01:01 PM             3,265
Waste-solid-AY.txt
04/24/2006  11:35 AM               240
Zero-Friction.log
             365 File(s)    731,229,780
bytes
               2 Dir(s)  154,590,855,168
bytes free
```

APPENDIX C

Best Estimate Soil
Best Estimate Concrete
Dome/Primary Tank μ=0.0

Results
Load Case Specific Input Files
File Listing

LIST OF FIGURES

Figure 5 BES-BEC Concrete Forces and Moments, Gravity Load Only

AY Primary Tank, Best Estimate Soil (Geomatrix), Gravity Only, Best Estimate Concrete, 422 in. Waste Level at 1.7 SpG, Dome Mu=0.0

ANSYS MAXIMUMS BY PATH

PNNL Section No.	Path (in.)	Hoop Force (kip/ft) AY-BES-BEC No Friction	Meridonal Force (kip/ft) AY-BES-BEC No Friction	-In-Plane Shear Force (kip/ft) AY-BES-BEC No Friction	Hoop Moment (ft*kip/ft) AY-BES-BEC No Friction	Meridonal Moment (ft*kip/ft) AY-BES-BEC No Friction	Through-Wall Shear Force (kip/ft) AY-BES-BEC No Friction
2	**67.727**	-70.830	-75.440	-0.121	-7.786	-4.485	1.980
3	**105.668**	-64.760	-73.630	-0.165	-5.401	-1.666	1.186
4	**137.069**	-58.850	-71.690	0.227	-3.713	0.950	1.328
6	**182.849**	-52.050	-68.510	-0.205	-2.262	2.109	0.272
8	**226.563**	-46.840	-66.100	-0.072	-1.802	0.550	-0.750
9	**275.566**	-42.200	-63.790	-0.193	-1.842	-1.287	-0.728
11	**325.690**	-33.970	-61.810	-0.152	-2.255	-4.397	-0.690
13	**372.305**	-24.170	-59.760	-0.055	-4.766	-5.293	-0.389
17	**423.427**	-8.356	-57.680	0.041	-2.340	-3.164	2.144
20	**468.308**	31.770	-55.230	-0.072	-8.196	14.930	8.327
22	**515.312**	15.570	-56.510	-0.054	4.428	28.330	-3.269
24	**549.725**	1.298	-55.010	0.036	2.261	12.400	-6.621
26	**585.819**	-11.230	-56.830	0.028	0.109	0.600	-2.789
30	**636.369**	-23.350	-58.880	0.022	-0.476	-2.639	0.802
33	**685.619**	-27.870	-60.240	0.018	-0.089	-0.495	0.342
35	**732.719**	-31.420	-61.620	0.015	0.040	0.221	-0.061
38	**778.219**	-27.850	-63.000	0.012	-0.151	-0.835	-0.224
41	**821.369**	-28.300	-64.800	0.019	-0.038	-0.211	-0.146
43	**874.169**	-17.480	-38.580	0.046	-0.422	-2.327	-0.195
46	**930.544**	-35.870	-67.240	0.429	-0.894	-4.690	-0.725
48	**977.629**	-2.196	-10.660	0.686	-3.352	16.400	-9.449
51	**1019.647**	-1.396	-15.300	1.259	-1.453	16.110	9.980
53	**1060.156**	-0.206	-5.153	0.383	0.613	2.770	-2.588
55	**1109.695**	1.700	-2.394	0.349	0.133	0.363	0.416
57	**1155.770**	0.948	0.136	0.076	0.018	0.058	-0.092
58	**1211.956**	1.406	1.146	0.029	0.023	0.059	0.077
59	**1281.707**	1.177	1.271	-0.014	0.020	0.094	-0.064
60	**1330.557**	1.078	1.189	-0.014	-0.007	-0.048	-0.085
61	**1374.857**	0.838	1.643	-0.069	0.012	0.019	0.203
62	**1417.007**	3.527	3.559	-0.041	0.119	0.381	-0.087

Note: Meridonal/Hoop Forces and Meridonal/Hoop Moments are Reversed in Highlighted Sections.

Figure 6 BES-BEC Concrete Forces and Moments, Gravity and Seismic Load

5/26/2006, 9:26 AM

AY- Primary Tank, Best Estimate Soil (Geomatrix), Best Estimate Concrete, 422 in. Waste Level at 1.7 SpG, Dome Friction = 0.0

ANSYS MAXIMUMS BY PATH

PNNL Section No.	Path (in.)	Seismic Hoop Force (kip/ft) AY-BES-BEC Mu=0.0	Seismic Meridonal Force (kip/ft) AY-BES-BEC Mu=0.0	Seismic -In-Plane Shear Force (kip/ft) AY-BES-BEC Mu=0.0	Seismic Hoop Moment (ft*kip/ft) AY-BES-BEC Mu=0.0	Seismic Meridonal Moment (ft*kip/ft) AY-BES-BEC Mu=0.0	Seismic Through-Wall Shear Force (kip/ft) AY-BES-BEC Mu=0.0
2	**67.727**	-96.990	-103.800	5.455	-15.970	-14.010	3.772
3	**105.668**	-87.560	-101.000	7.732	-12.410	-10.230	2.708
4	**137.069**	-80.490	-97.300	8.967	-9.279	7.364	3.250
6	**182.849**	-71.960	-91.050	9.832	-5.319	5.607	2.464
8	**226.563**	-66.210	-85.130	10.650	-3.426	-7.360	1.541
9	**275.566**	-64.500	-79.580	11.500	-3.054	-4.729	1.256
11	**325.690**	-56.180	-76.380	13.240	-3.128	-6.425	1.306
13	**372.305**	-52.830	-73.090	14.970	-6.296	-7.521	0.921
17	**423.427**	-19.080	-70.040	16.710	-3.184	-7.061	2.879
20	**468.308**	66.740	-66.420	19.010	-11.600	19.580	9.800
22	**515.312**	25.810	-66.150	20.470	5.810	34.690	4.471
24	**549.725**	6.202	-63.690	19.230	2.764	15.110	8.136
26	**585.819**	-16.160	-65.540	19.040	0.173	0.913	3.341
30	**636.369**	-28.120	-66.850	19.070	-0.568	-3.127	0.959
33	**685.619**	-32.850	-68.520	19.450	-0.133	-0.675	0.393
35	**732.719**	-36.640	-70.070	20.100	0.073	0.381	0.107
38	**778.219**	-32.100	-71.440	20.710	-0.191	-1.035	0.332
41	**821.369**	-33.000	-73.820	22.180	-0.068	-0.328	0.217
43	**874.169**	-20.010	-44.210	15.290	-0.618	-3.401	0.455
46	**930.544**	-63.010	-77.170	26.190	-1.048	-5.926	1.396
48	**977.629**	-10.740	-14.940	7.707	-3.881	18.840	10.860
51	**1019.647**	-28.080	-22.390	11.220	-1.770	18.510	11.460
53	**1060.156**	5.757	-10.540	5.866	0.749	3.449	3.622
55	**1109.695**	12.980	-6.658	5.244	0.182	0.504	0.525
57	**1155.770**	4.389	2.565	2.576	0.027	0.080	0.128
58	**1211.956**	4.576	2.769	1.849	0.035	0.076	0.129
59	**1281.707**	3.301	2.474	1.235	0.027	0.119	0.137
60	**1330.557**	2.753	2.319	0.921	-0.011	-0.059	0.124
61	**1374.857**	1.828	3.119	0.924	0.014	0.025	0.277
62	**1417.007**	7.042	6.091	1.169	0.153	0.446	0.174

Note: Meridonal/Hoop Forces and Meridonal/Hoop Moments are Reversed in Highlighted Sections.

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C:\Users\Bruce\2008-000 PNNL\2008-006 J-Bolts\BES-BEC-Seismic\AY-2D-NL-BES-BEC Conc Tank Demand Seismic Mu=0.xls
Page 1

Figure 7 BES-BEC Concrete Forces and Moments, Seismic Load Only

5/26/2006, 9:27 AM

AY- Primary Tank, Best Estimate Soil (Geomatrix), Best Estimate Concrete, 422 in. Waste Level at 1.7 SpGm Dome Friction = 0.0

ANSYS MAXIMUMS BY PATH

PNNL Section No.	Path (in.)	Seismic Only Hoop Force (kip/ft) AY-BES-BEC Mu=0.0	Seismic Only Meridonal Force (kip/ft) AY-BES-BEC Mu=0.0	Seismic Only - In-Plane Shear Force (kip/ft) AY-BES-BEC Mu=0.0	Seismic Only Hoop Moment (ft*kip/ft) AY-BES-BEC Mu=0.0	Seismic Only Meridonal Moment (ft*kip/ft) AY-BES-BEC Mu=0.0	Seismic Only Through-Wall Shear Force (kip/ft) AY-BES-BEC Mu=0.0
2	**67.727**	28.090	28.360	5.470	9.058	9.525	2.016
3	**105.668**	26.310	27.380	7.781	7.519	8.855	1.664
4	**137.069**	22.430	25.630	9.034	5.591	6.500	2.011
6	**182.849**	21.490	22.560	9.885	3.364	4.048	2.291
8	**226.563**	21.550	19.070	10.660	1.864	7.013	0.905
9	**275.566**	22.700	15.790	11.476	1.445	3.660	0.812
11	**325.690**	22.390	14.570	13.233	1.096	2.031	0.760
13	**372.305**	28.990	13.330	14.989	1.830	2.482	0.532
17	**423.427**	10.822	12.360	16.743	0.890	4.042	0.794
20	**468.308**	39.685	11.190	19.057	4.210	5.377	1.866
22	**515.312**	12.231	9.670	20.511	1.611	7.590	1.452
24	**549.725**	5.751	8.770	19.258	0.595	3.091	1.812
26	**585.819**	4.970	8.800	19.062	0.093	0.458	0.606
30	**636.369**	4.870	8.330	19.088	0.093	0.492	0.159
33	**685.619**	5.320	8.920	19.465	0.044	0.181	0.056
35	**732.719**	5.940	10.140	20.112	0.037	0.162	0.046
38	**778.219**	4.650	11.210	20.720	0.041	0.200	0.109
41	**821.369**	5.390	12.510	22.175	0.032	0.128	0.076
43	**874.169**	2.850	8.720	15.287	0.236	1.298	0.311
46	**930.544**	31.452	15.110	26.199	0.188	1.682	0.983
48	**977.629**	9.313	4.341	7.045	0.809	3.980	2.299
51	**1019.647**	28.525	7.584	10.118	0.703	4.090	2.202
53	**1060.156**	5.892	5.387	5.521	0.173	0.820	1.103
55	**1109.695**	11.409	4.399	4.929	0.062	0.195	0.135
57	**1155.770**	3.454	2.611	2.511	0.009	0.028	0.052
58	**1211.956**	3.423	1.937	1.870	0.013	0.024	0.055
59	**1281.707**	2.224	1.631	1.232	0.009	0.029	0.073
60	**1330.557**	1.677	1.592	0.912	0.007	0.016	0.064
61	**1374.857**	0.992	1.776	0.862	0.003	0.009	0.128
62	**1417.007**	3.568	3.312	1.141	0.040	0.065	0.137

Note: Meridonal/Hoop Forces and Meridonal/Hoop Moments are Reversed in Highlighted Sections.

Figure 8 BES-BEC Primary Tank Stresses, Shell Top, Gravity Load Only

AY Primary Tank, Best Estimate Soil, Gravity Only, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, Mu=0.0

M&D Starting M&D Element No.	Path (in.)	Shell Top Surface (inside - waste side) AY-NL-BES-BEC Gravity Only Hoop Stress (lbs/in^2) Top, Mu=0.0	AY-NL-BES-BEC Gravity Only Meridional Stress (lbs/in^2) Top, Mu=0.0	AY-NL-BES-BEC Gravity Only Stress Intensity (lbs/in^2) Top, Mu=0.0	AY-NL-BES-BEC Gravity Only In-Plane Shear Stress (lbs/in^2) Top, Mu=0.0	AY-NL-BES-BEC Gravity Only In-Plane Shear Force Stress (lbs/in^2) Top, Mu=0.0	AY-NL-BES-BEC Gravity Only Thru-Thickness Shear Stress (lbs/in^2) Top, Mu=0.0
762	**67.33**	-1831.25	0.00	1831.25	4.44	9.90	-0.18
782	**105.04**	-1780.56	-2875.69	2876.39	7.50	-24.32	0.03
802	**136.24**	-1706.94	-1977.08	1977.78	10.31	21.85	-0.02
822	**181.71**	-1159.72	-2303.47	2303.47	9.04	-4.63	0.03
842	**225.10**	-1213.89	-1347.22	1347.22	3.51	-1.65	-0.12
862	**273.66**	-525.42	-1688.89	1688.89	9.01	2.50	-0.03
882	**323.27**	-536.32	-767.36	767.36	6.67	-9.71	0.04
902	**369.20**	373.89	-1034.03	1406.94	3.08	-2.05	-0.02
922	**419.20**	637.71	-127.92	765.97	-0.85	7.40	-0.01
942	**444.11**	1061.11	-1479.86	2540.97	2.05	-8.34	0.03
962	**471.06**	1083.33	197.01	1083.33	1.76	-3.59	-0.02
982	**503.51**	1891.67	-194.79	2086.81	1.60	2.79	-0.02
1002	**527.76**	2982.64	-200.69	3184.72	1.86	-15.94	0.00
1022	**554.76**	4008.33	139.79	4009.03	1.41	-7.76	0.00
1042	**582.26**	5630.56	-187.08	5817.36	1.45	-7.22	0.00
1062	**609.26**	7340.28	-22.65	7361.11	1.45	-7.73	0.00
1082	**636.26**	8986.11	-307.43	9298.61	1.45	-10.24	0.00
1102	**663.26**	10472.22	216.94	10472.22	1.57	0.23	0.00
1122	**688.61**	12395.83	-448.47	12847.22	1.59	3.28	0.00
1142	**711.96**	13833.33	-33.62	13868.06	1.58	-5.64	0.01
1162	**734.96**	15326.39	-18.34	15347.22	1.60	-6.66	0.01
1182	**757.91**	15395.83	-1859.03	17250.00	1.60	-8.85	0.01
1202	**782.81**	12805.56	2082.64	12805.56	1.13	-17.77	0.01
1222	**809.76**	12430.56	-325.42	12750.00	1.04	-6.97	-0.02
1242	**836.76**	13722.22	-151.39	13875.00	1.00	-4.13	-0.03
1262	**863.76**	15152.78	294.51	15152.78	0.97	-5.31	0.08
1282	**889.76**	13138.89	-4813.89	17951.39	3.63	-14.08	-0.23
1302	**906.85**	4356.25	-9284.72	13638.89	16.69	147.85	-1.97
1322	**916.04**	4314.58	7555.56	7597.22	14.44	393.82	-3.86
1342	**934.63**	3121.53	8840.28	8881.94	-454.72	10.23	-125.76
1362	**974.63**	-75.97	-1540.97	1552.78	118.54	-3.35	42.49
1382	**1040.78**	969.44	1885.42	1891.67	-74.03	2.06	-26.15
1402	**1110.53**	62.29	-1102.78	1175.00	93.47	-2.94	37.14

Figure 9 BES-BEC Primary Tank Stresses, Shell Middle, Gravity Load Only

AY Primary Tank, Best Estimate Soil, Horizontal and Vertical Seismic Input, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, Mu=0.0

M&D Starting M&D Element No.	Path (in.)	Shell Mid-Plane					
		AY-NL-BES-BEC Hoop Stress Seismic Only (LBS/in^2) mid, Mu=0.0	AY-NL-BES-BEC Meridional Stress Seismic Only (LBS/in^2) mid, Mu=0.0	AY-NL-BES-BEC Stress Seismic Only Intensity (LBS/in^2) mid, Mu=0.0	AY-NL-BES-BEC In-Plane Shear Stress Seismic Only (LBS/in^2) mid, Mu=0.0	AY-NL-BES-BEC In-Plane Shear Force Stress Seismic Only (LBS/in^2) mid, Mu=0.0	AY-NL-BES-BEC Thru-Thickness Shear Stress Seismic Only (LBS/in^2) mid, Mu=0.0
762	**67.33**	1070.14	931.94	993.75	221.80	8.56	3.47
782	**105.04**	927.08	1120.14	1120.14	360.60	21.46	1.36
802	**136.24**	1054.86	1017.36	1018.06	387.57	22.91	1.30
822	**181.71**	529.17	850.69	850.69	394.78	10.50	1.68
842	**225.10**	1334.06	700.00	796.53	778.11	23.94	7.39
862	**273.66**	871.81	572.92	1406.94	1349.21	12.65	5.77
882	**323.27**	2959.86	608.06	2352.08	1465.29	34.69	15.60
902	**369.20**	1339.38	721.81	1770.14	1291.46	26.80	7.43
922	**419.20**	2171.32	833.19	3174.31	2079.74	52.17	6.91
942	**444.11**	2185.42	1151.11	3610.42	2428.39	251.57	9.60
962	**471.06**	6572.22	1061.32	7620.83	2496.50	17.60	9.29
982	**503.51**	4506.25	1028.68	5214.58	2723.07	89.18	8.64
1002	**527.76**	3661.04	1144.72	3451.39	2688.32	38.22	2.38
1022	**554.76**	4079.38	938.61	3817.36	1720.23	33.60	1.71
1042	**582.26**	5729.03	1022.43	5161.81	1468.85	23.17	1.30
1062	**609.26**	7062.29	1099.38	5968.06	1244.37	19.22	1.48
1082	**636.26**	8358.13	1162.71	7257.64	1050.72	12.04	1.45
1102	**663.26**	9233.33	1216.39	8102.08	863.31	16.46	1.48
1122	**688.61**	10603.47	1226.74	9479.86	875.54	32.68	1.44
1142	**711.96**	11027.78	1220.56	9936.11	1209.85	39.08	1.45
1162	**734.96**	11351.39	1182.29	10296.53	1209.85	45.33	1.39
1182	**757.91**	10928.47	1137.01	9957.64	1557.26	38.42	1.38
1202	**782.81**	7717.36	677.57	7154.86	1292.43	9.16	2.64
1222	**809.76**	7291.67	596.18	6825.00	1618.19	14.38	1.95
1242	**836.76**	7387.50	497.64	7029.17	1946.56	12.79	1.77
1262	**863.76**	7520.83	409.86	7291.67	2284.81	15.29	0.98
1282	**889.76**	6243.06	377.71	6236.11	2601.25	51.20	4.04
1302	**906.85**	1416.67	362.22	1555.56	2308.34	101.61	23.08
1322	**916.04**	2892.36	245.08	3186.81	2304.93	246.32	27.75
1342	**934.63**	3366.67	414.93	3573.68	1946.08	6.17	79.57
1362	**974.63**	2819.03	772.92	5320.97	2962.95	2.09	26.51
1382	**1040.78**	1935.69	481.46	3205.63	1860.38	1.26	16.10
1402	**1110.53**	1339.65	422.36	1258.33	911.03	1.79	56.84

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AY-2D-NL-BES-BEC Pri Tank Stress Seismic Only Mu=0.xls, Stress Max

Figure 10 BES-BEC Primary Tank Stresses, Shell Bottom, Gravity Load Only

AY Primary Tank, Best Estimate Soil, Gravity Only, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, Mu=0.0

M&D Starting M&D Element No.	Path (in.)	Shell Bottom Surface (outside - away from waste) AY-NL-BES-BEC Gravity Only Hoop Stress (lbs/in^2) Bot, Mu=0.0	AY-NL-BES-BEC Gravity Only Meridional Stress (lbs/in^2) Bot, Mu=0.0	AY-NL-BES-BEC Gravity Only Stress Intensity (lbs/in^2) Bot, Mu=0.0	AY-NL-BES-BEC Gravity Only In-Plane Shear Stress (lbs/in^2) Bot, Mu=0.0	AY-NL-BES-BEC Gravity Only In-Plane Shear Force Stress (lbs/in^2) Bot, Mu=0.0	AY-NL-BES-BEC Gravity Only Thru-Thickness Shear Stress (lbs/in^2) Bot, Mu=0.0
762	**67.33**	-2089.58	-2247.92	2247.92	4.80	9.90	-0.18
782	**105.04**	-1608.33	-2164.58	2164.58	6.81	-24.32	0.03
802	**136.24**	-1958.33	-2723.61	2724.31	-8.69	21.85	-0.02
822	**181.71**	-1042.36	-1852.78	1852.78	-7.49	-4.63	0.03
842	**225.10**	-1506.94	-2286.81	2286.81	2.79	-1.65	-0.12
862	**273.66**	-431.94	-1331.94	1331.94	7.61	2.50	-0.03
882	**323.27**	-788.89	-1580.56	1581.25	6.13	-9.71	0.04
902	**369.20**	468.61	-681.11	1149.31	2.95	-2.05	-0.02
922	**419.20**	428.06	-792.36	1218.75	-0.77	7.40	-0.01
942	**444.11**	1846.53	1159.72	1847.22	1.72	-8.34	0.03
962	**471.06**	896.53	-433.47	1329.17	1.71	-3.59	-0.02
982	**503.51**	1942.36	-27.24	1968.75	1.47	2.79	-0.02
1002	**527.76**	3033.33	-34.79	3073.61	1.68	-15.94	0.00
1022	**554.76**	3871.53	-320.28	4190.97	1.21	-7.76	0.00
1042	**582.26**	5682.64	-12.07	5697.92	1.28	-7.22	0.00
1062	**609.26**	7284.72	-192.71	7479.17	1.30	-7.73	0.00
1082	**636.26**	9104.17	79.58	9104.17	1.33	-10.24	0.00
1102	**663.26**	10270.83	-461.18	10729.17	1.49	0.23	0.00
1122	**688.61**	12583.33	190.21	12583.33	1.52	3.28	0.00
1142	**711.96**	13770.83	-243.40	14013.89	1.71	-5.64	0.01
1162	**734.96**	15250.00	-272.71	15520.83	1.71	-6.66	0.01
1182	**757.91**	16416.67	1559.72	16416.67	1.53	-8.85	0.01
1202	**782.81**	11493.06	-2286.11	13777.78	0.98	-17.77	0.01
1222	**809.76**	12555.56	107.78	12555.56	1.22	-6.97	-0.02
1242	**836.76**	13743.06	-86.74	13826.39	1.03	-4.13	-0.03
1262	**863.76**	14895.83	-546.53	15444.44	1.40	-5.31	0.08
1282	**889.76**	15944.44	4541.67	15944.44	4.74	-14.08	-0.23
1302	**906.85**	9590.28	9013.89	9597.22	11.15	147.85	-1.97
1322	**916.04**	-827.78	-7437.50	7479.17	5.17	393.82	-3.86
1342	**934.63**	-2166.67	-8243.06	8284.72	481.04	10.23	-125.76
1362	**974.63**	1240.97	2766.67	2777.08	-123.06	-3.35	42.49
1382	**1040.78**	164.51	-754.17	928.47	74.03	2.06	-26.15
1402	**1110.53**	1078.47	2273.61	2282.64	-96.39	-2.94	37.14

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AY-2D-NL-BES-BEC Pri Tank Stress Gravity Mu=0.0.xls, Stress Max

Figure 11 BES-BEC Primary Tank Stresses, Shell Top, Gravity Plus Seismic Load

AY Primary Tank, Best Estimate Soil, Horizontal and Vertical Seismic Input, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG

		Shell Top Surface (inside - waste side)					
M&D Starting M&D Element No.	Path (in.)	AY-NL-BES-BEC Seismic Hoop Stress (lbs/in^2) Top, Mu=0.0	AY-NL-BES-BEC Seismic Meridional Stress (lbs/in^2) Top, Mu=0.0	AY-NL-BES-BEC Seismic Stress Intensity (lbs/in^2) Top, Mu=0.0	AY-NL-BES-BEC Seismic In-Plane Shear Stress (lbs/in^2) Top, Mu=0.0	AY-NL-BES-BEC Seismic In-Plane Shear Force Stress (lbs/in^2) Top, Mu=0.0	AY-NL-BES-BEC Seismic Thru-Thickness Shear Stress (lbs/in^2) Top, Mu=0.0
762	**67.33**	-2751.39	0.00	2751.39	222.71	16.56	3.45
782	**105.04**	-2664.58	-4080.56	4081.25	366.67	-40.78	1.38
802	**136.24**	-2620.14	-2975.00	3001.39	392.22	39.54	-1.30
822	**181.71**	-1697.92	-3217.36	3218.06	402.36	-13.92	-1.68
842	**225.10**	-2053.47	-2192.36	2193.06	779.86	-24.80	-7.34
862	**273.66**	-1263.19	-2439.58	2942.36	-1347.92	14.03	-5.77
882	**323.27**	-2229.86	-1479.17	3502.08	-1454.17	-40.40	-15.59
902	**369.20**	1588.19	-2122.22	3220.14	-1295.14	-28.77	-7.42
922	**419.20**	2565.28	-556.88	4152.08	-2073.61	59.53	6.90
942	**444.11**	3240.97	-2440.97	5768.75	2409.72	-244.44	9.59
962	**471.06**	7312.50	2345.83	9326.39	2488.89	-21.16	9.27
982	**503.51**	5770.14	-2259.72	8041.67	2767.36	91.88	8.63
1002	**527.76**	5602.08	-648.96	6794.44	2704.86	-54.13	2.38
1022	**554.76**	8062.50	1656.94	8062.50	1718.06	-41.35	-1.71
1042	**582.26**	10868.06	-906.94	10868.06	1488.89	-19.96	1.30
1062	**609.26**	13180.56	-1279.86	13187.50	-1257.64	-26.94	1.49
1082	**636.26**	15666.67	-1254.17	15666.67	-1052.08	-15.31	1.45
1102	**663.26**	17604.17	1470.83	17604.17	-870.14	-16.24	-1.48
1122	**688.61**	19881.94	-1324.31	19881.94	-876.39	35.96	-1.44
1142	**711.96**	21562.50	-1385.42	21562.50	-952.08	-44.68	-1.44
1162	**734.96**	22868.06	-1225.00	22868.06	1565.97	38.69	-1.38
1182	**757.91**	22361.11	-2354.86	24208.33	1565.97	-47.23	-1.37
1202	**782.81**	18125.00	3386.11	18125.00	1304.17	-25.75	-2.64
1222	**809.76**	17201.39	-759.03	17395.83	1612.50	-9.84	-1.96
1242	**836.76**	18798.61	-698.61	18798.61	1943.06	-16.83	-1.78
1262	**863.76**	20347.22	936.11	20347.22	2278.47	-14.71	0.98
1282	**889.76**	17222.22	-7298.61	24527.78	2651.39	-64.73	4.12
1302	**906.85**	5454.17	-15229.17	18861.11	2477.08	223.89	23.76
1322	**916.04**	5643.06	11604.17	11652.78	2459.72	636.81	27.13
1342	**934.63**	5279.86	13041.67	13097.22	-2413.89	15.03	-188.61
1362	**974.63**	3104.86	-2498.61	6115.28	-2852.78	-5.10	64.64
1382	**1040.78**	2693.75	2625.69	3895.14	-1923.61	3.13	-39.88
1402	**1110.53**	1617.36	-1906.25	2217.36	-829.86	-4.49	56.84

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AY-2D-NL-BES-BEC Pri Tank Stress Seismic Mu=0.xls, Stress Max

Figure 12 BES-BEC Primary Tank Stresses, Shell Middle, Gravity Plus Seismic Load

AY Primary Tank, Best Estimate Soil, Horizontal and Vertical Seismic Input, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG

		Shell Mid-Plane					
M&D Starting M&D Element No.	Path (in.)	AY-NL-BES-BEC Seismic Hoop Stress (lbs/in^2) Mid, Mu=0.0	AY-NL-BES-BEC Seismic Meridional Stress (lbs/in^2) Mid, Mu=0.0	AY-NL-BES-BEC Seismic Stress Intensity (lbs/in^2) Mid, Mu=0.0	AY-NL-BES-BEC Seismic In-Plane Shear Stress (lbs/in^2) Mid, Mu=0.0	AY-NL-BES-BEC Seismic In-Plane Shear Force Stress (lbs/in^2) Mid, Mu=0.0	AY-NL-BES-BEC Seismic Thru-Thickness Shear Stress (lbs/in^2) Mid, Mu=0.0
762	**67.33**	-2945.14	-2830.56	2945.14	221.32	16.56	3.45
782	**105.04**	-2597.22	-3639.58	3640.28	358.54	-40.78	1.38
802	**136.24**	-2878.47	-3367.36	3368.06	385.07	39.54	-1.30
822	**181.71**	-1628.47	-2927.78	2927.78	395.83	-13.92	-1.68
842	**225.10**	-2439.58	-2516.67	2585.42	778.47	-24.80	-7.34
862	**273.66**	-1159.72	-2082.64	2913.89	-1347.92	14.03	-5.77
882	**323.27**	-2493.06	-1729.86	3522.92	-1461.81	-40.40	-15.59
902	**369.20**	1622.92	-1491.67	3034.03	-1292.36	-28.77	-7.42
922	**419.20**	2704.17	-1238.19	4161.81	-2080.56	59.53	6.90
942	**444.11**	3639.58	-1288.19	5220.14	2428.47	-244.44	9.59
962	**471.06**	7555.56	-1179.86	8722.22	2496.53	-21.16	9.27
982	**503.51**	6120.14	-1138.19	7236.11	2722.92	91.88	8.63
1002	**527.76**	5933.33	-1261.11	6577.08	2688.19	-54.13	2.38
1022	**554.76**	7847.22	-1028.47	7847.22	1720.14	-41.35	-1.71
1042	**582.26**	10916.67	-1120.14	10916.67	1468.75	-19.96	1.30
1062	**609.26**	13111.11	-1204.86	13111.11	-1244.44	-26.94	1.49
1082	**636.26**	15777.78	-1278.47	15777.78	-1050.69	-15.31	1.45
1102	**663.26**	17465.28	-1340.28	17465.28	-863.19	-16.24	-1.48
1122	**688.61**	19979.17	-1358.33	19979.17	-875.69	35.96	-1.44
1142	**711.96**	21597.22	-1359.03	21597.22	-1209.72	-44.68	-1.44
1162	**734.96**	22861.11	-1325.69	22861.11	-1209.72	38.69	-1.38
1182	**757.91**	23076.39	-1279.17	23076.39	1557.64	-47.23	-1.37
1202	**782.81**	17305.56	-778.47	17312.50	1292.36	-25.75	-2.64
1222	**809.76**	17263.89	-702.78	17263.89	1618.06	-9.84	-1.96
1242	**836.76**	18770.83	-614.72	18770.83	1946.53	-16.83	-1.78
1262	**863.76**	20263.89	-532.85	20263.89	2284.72	-14.71	0.98
1282	**889.76**	19340.28	-508.82	19590.28	2601.39	-64.73	4.12
1302	**906.85**	8375.00	-490.42	8743.06	2308.33	223.89	23.76
1322	**916.04**	4599.31	300.42	5297.92	2304.17	636.81	27.13
1342	**934.63**	3848.61	538.54	4101.39	-1931.94	15.03	-188.61
1362	**974.63**	3404.17	894.44	5945.83	-2965.97	-5.10	64.64
1382	**1040.78**	2501.39	754.86	3775.00	-1861.11	3.13	-39.88
1402	**1110.53**	1833.33	834.72	1850.00	-912.50	-4.49	56.84

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AY-2D-NL-BES-BEC Pri Tank Stress Seismic Mu=0.xls, Stress Max

Figure 13 BES-BEC Primary Tank Stresses, Shell Bottom, Gravity Plus Seismic Load

AY Primary Tank, Best Estimate Soil, Horizontal and Vertical Seismic Input, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG

M&D Starting M&D Element No.	Path (in.)	Shell Bottom Surface (outside - away from waste) AY-NL-BES-BEC Seismic Hoop Stress (lbs/in^2) Bot, Mu=0.0	AY-NL-BES-BEC Seismic Meridional Stress (lbs/in^2) Bot, Mu=0.0	AY-NL-BES-BEC Seismic Stress Intensity (lbs/in^2) Bot, Mu=0.0	AY-NL-BES-BEC Seismic In-Plane Shear Stress (lbs/in^2) Bot, Mu=0.0	AY-NL-BES-BEC Seismic In-Plane Shear Force Stress (lbs/in^2) Bot, Mu=0.0	AY-NL-BES-BEC Seismic Thru-Thickness Shear Stress (lbs/in^2) Bot, Mu=0.0
762	**67.33**	-3184.72	-3261.11	3261.11	219.93	16.56	3.45
782	**105.04**	-2529.86	-3320.83	3325.00	350.49	-40.78	1.38
802	**136.24**	-3136.11	-3881.25	3882.64	377.85	39.54	-1.30
822	**181.71**	-1559.03	-2680.56	2680.56	389.65	-13.92	-1.68
842	**225.10**	-2827.78	-3382.64	3382.64	777.08	-24.80	-7.34
862	**273.66**	-1056.25	-1872.92	2886.11	-1347.22	14.03	-5.77
882	**323.27**	-2786.11	-2894.44	3636.81	-1469.44	-40.40	-15.59
902	**369.20**	1657.64	-1212.50	2859.72	-1290.28	-28.77	-7.42
922	**419.20**	2843.06	-2661.81	4190.97	-2087.50	59.53	6.90
942	**444.11**	4038.89	2418.06	4972.22	2447.22	-244.44	9.59
962	**471.06**	7798.61	-824.31	8131.94	2504.17	-21.16	9.27
982	**503.51**	6470.14	634.65	6543.06	2679.17	91.88	8.63
1002	**527.76**	6264.58	-2820.83	6442.36	2670.83	-54.13	2.38
1022	**554.76**	7770.83	-791.67	7784.72	1722.22	-41.35	-1.71
1042	**582.26**	11159.72	-1333.33	11166.67	1461.81	-19.96	1.30
1062	**609.26**	13041.67	-1196.53	13041.67	-1231.25	-26.94	1.49
1082	**636.26**	15895.83	1427.78	15895.83	-1048.61	-15.31	1.45
1102	**663.26**	17340.28	-1394.44	17340.28	-855.56	-16.24	-1.48
1122	**688.61**	20076.39	1421.53	20076.39	-875.00	35.96	-1.44
1142	**711.96**	21625.00	-1345.83	21625.00	-1204.17	-44.68	-1.44
1162	**734.96**	22861.11	-1426.39	22861.11	-1204.17	38.69	-1.38
1182	**757.91**	23791.67	3031.94	23791.67	1548.61	-47.23	-1.37
1202	**782.81**	16555.56	-2947.22	19145.83	1281.25	-25.75	-2.64
1222	**809.76**	17319.44	749.31	17319.44	1623.61	-9.84	-1.96
1242	**836.76**	18743.06	-553.47	18743.06	1950.00	-16.83	-1.78
1262	**863.76**	20180.56	-1831.94	20625.00	2290.97	-14.71	0.98
1282	**889.76**	21458.33	6854.86	21458.33	2551.39	-64.73	4.12
1302	**906.85**	12166.67	14250.00	14250.00	2138.89	223.89	23.76
1322	**916.04**	-5007.64	-11340.28	11388.89	2149.31	636.81	27.13
1342	**934.63**	-6385.42	-12430.56	12493.06	1791.67	15.03	-188.61
1362	**974.63**	3704.17	3975.00	6339.58	-3079.17	-5.10	64.64
1382	**1040.78**	2317.36	-1332.64	3925.69	-1799.31	3.13	-39.88
1402	**1110.53**	2061.11	3185.42	3198.61	-1000.00	-4.49	56.84

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AY-2D-NL-BES-BEC Pri Tank Stress Seismic Mu=0.xls, Stress Max

Figure 14 BES-BEC Primary Tank Stresses, Shell Top, Seismic Load Only

AY Primary Tank, Best Estimate Soil, Horizontal and Vertical Seismic Input, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, Mu=0.0

		Shell Top Surface (inside - waste side)					
M&D Starting M&D Element No.	Path (in.)	AY-NL-BES-BEC Hoop Stress Seismic Only (LBS/in^2) Top, Mu=0.0	AY-NL-BES-BEC Meridional Stress Seismic Only (LBS/in^2) Top, Mu=0.0	AY-NL-BES-BEC Stress Seismic Only Intensity (LBS/in^2) Top, Mu=0.0	AY-NL-BES-BEC In-Plane Shear Stress Seismic Only (LBS/in^2) Top, Mu=0.0	AY-NL-BES-BEC In-Plane Shear Force Stress Seismic Only (LBS/in^2) Top, Mu=0.0	AY-NL-BES-BEC Thru-Thickness Shear Stress Seismic Only (LBS/in^2) Top, Mu=0.0
762	**67.33**	954.86	0.00	930.56	222.13	8.56	3.47
782	**105.04**	975.69	1292.36	1292.36	369.21	21.46	1.36
802	**136.24**	923.61	1007.64	1033.33	394.64	22.91	1.30
822	**181.71**	566.25	980.56	979.86	401.21	10.50	1.68
842	**225.10**	1051.32	845.14	845.83	779.35	23.94	7.39
862	**273.66**	985.76	847.22	1257.64	1349.24	12.65	5.77
882	**323.27**	2753.96	721.97	2739.58	1457.74	34.69	15.60
902	**369.20**	1323.40	1300.90	1827.78	1294.24	26.80	7.43
922	**419.20**	1927.57	429.38	3390.97	2072.76	52.17	6.91
942	**444.11**	2195.83	1227.22	3233.33	2409.62	251.57	9.60
962	**471.06**	6235.42	2264.38	8249.31	2488.85	17.60	9.29
982	**503.51**	4314.58	2066.88	5961.81	2767.49	89.18	8.64
1002	**527.76**	3169.31	624.31	3610.42	2704.98	38.22	2.38
1022	**554.76**	4317.29	1737.29	4053.47	1718.16	33.60	1.71
1042	**582.26**	5636.51	721.53	5052.08	1488.98	23.17	1.30
1062	**609.26**	7089.65	1266.27	5890.97	1257.57	19.22	1.48
1082	**636.26**	8294.38	955.63	7391.67	1052.13	12.04	1.45
1102	**663.26**	9300.00	1530.00	8137.50	870.25	16.46	1.48
1122	**688.61**	10493.06	1201.18	9717.36	876.24	32.68	1.44
1142	**711.96**	11038.19	1351.80	9904.17	951.92	39.08	1.45
1162	**734.96**	11347.22	1206.66	10295.83	1565.49	45.33	1.39
1182	**757.91**	10622.92	1008.33	10679.86	1565.49	38.42	1.38
1202	**782.81**	8144.44	1990.90	8141.67	1303.73	9.16	2.64
1222	**809.76**	7236.11	548.26	6959.72	1612.63	14.38	1.95
1242	**836.76**	7400.69	666.11	6993.75	1943.08	12.79	1.77
1262	**863.76**	7520.83	746.67	7513.89	2278.53	15.29	0.98
1282	**889.76**	5291.67	3212.50	8479.17	2651.26	51.20	4.04
1302	**906.85**	1497.22	6000.00	5277.78	2477.04	101.61	23.08
1322	**916.04**	1630.56	5605.56	4069.44	2460.70	246.32	27.75
1342	**934.63**	2162.50	5572.22	4962.50	1963.06	6.17	79.57
1362	**974.63**	3173.06	1105.69	4580.56	2967.29	2.09	26.51
1382	**1040.78**	1737.50	1058.33	2011.81	1850.69	1.26	16.10
1402	**1110.53**	1556.71	1015.94	1046.53	920.21	1.79	22.58

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AY-2D-NL-BES-BEC Pri Tank Stress Seismic Only Mu=0.xls, Stress Max

Figure 15 BES-BEC Primary Tank Stresses, Shell Middle, Seismic Load Only

AY Primary Tank, Best Estimate Soil, Horizontal and Vertical Seismic Input, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, Mu=0.0

		Shell Mid-Plane					
M&D Starting M&D Element No.	Path (in.)	AY-NL-BES-BEC Hoop Stress Seismic Only (LBS/in^2) mid, Mu=0.0	AY-NL-BES-BEC Meridional Stress Seismic Only (LBS/in^2) mid, Mu=0.0	AY-NL-BES-BEC Stress Seismic Only Intensity (LBS/in^2) mid, Mu=0.0	AY-NL-BES-BEC In-Plane Shear Stress Seismic Only (LBS/in^2) mid, Mu=0.0	AY-NL-BES-BEC In-Plane Shear Force Stress Seismic Only (LBS/in^2) mid, Mu=0.0	AY-NL-BES-BEC Thru-Thickness Shear Stress Seismic Only (LBS/in^2) mid, Mu=0.0
762	**67.33**	1070.14	931.94	993.75	221.80	8.56	3.47
782	**105.04**	927.08	1120.14	1120.14	360.60	21.46	1.36
802	**136.24**	1054.86	1017.36	1018.06	387.57	22.91	1.30
822	**181.71**	529.17	850.69	850.69	394.78	10.50	1.68
842	**225.10**	1334.06	700.00	796.53	778.11	23.94	7.39
862	**273.66**	871.81	572.92	1406.94	1349.21	12.65	5.77
882	**323.27**	2959.86	608.06	2352.08	1465.29	34.69	15.60
902	**369.20**	1339.38	721.81	1770.14	1291.46	26.80	7.43
922	**419.20**	2171.32	833.19	3174.31	2079.74	52.17	6.91
942	**444.11**	2185.42	1151.11	3610.42	2428.39	251.57	9.60
962	**471.06**	6572.22	1061.32	7620.83	2496.50	17.60	9.29
982	**503.51**	4506.25	1028.68	5214.58	2723.07	89.18	8.64
1002	**527.76**	3661.04	1144.72	3451.39	2688.32	38.22	2.38
1022	**554.76**	4079.38	938.61	3817.36	1720.23	33.60	1.71
1042	**582.26**	5729.03	1022.43	5161.81	1468.85	23.17	1.30
1062	**609.26**	7062.29	1099.38	5968.06	1244.37	19.22	1.48
1082	**636.26**	8358.13	1162.71	7257.64	1050.72	12.04	1.45
1102	**663.26**	9233.33	1216.39	8102.08	863.31	16.46	1.48
1122	**688.61**	10603.47	1226.74	9479.86	875.54	32.68	1.44
1142	**711.96**	11027.78	1220.56	9936.11	1209.85	39.08	1.45
1162	**734.96**	11351.39	1182.29	10296.53	1209.85	45.33	1.39
1182	**757.91**	10928.47	1137.01	9957.64	1557.26	38.42	1.38
1202	**782.81**	7717.36	677.57	7154.86	1292.43	9.16	2.64
1222	**809.76**	7291.67	596.18	6825.00	1618.19	14.38	1.95
1242	**836.76**	7387.50	497.64	7029.17	1946.56	12.79	1.77
1262	**863.76**	7520.83	409.86	7291.67	2284.81	15.29	0.98
1282	**889.76**	6243.06	377.71	6236.11	2601.25	51.20	4.04
1302	**906.85**	1416.67	362.22	1555.56	2308.34	101.61	23.08
1322	**916.04**	2892.36	245.08	3186.81	2304.93	246.32	27.75
1342	**934.63**	3366.67	414.93	3573.68	1946.08	6.17	79.57
1362	**974.63**	2819.03	772.92	5320.97	2962.95	2.09	26.51
1382	**1040.78**	1935.69	481.46	3205.63	1860.38	1.26	16.10
1402	**1110.53**	1339.65	422.36	1258.33	911.03	1.79	56.84

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AY-2D-NL-BES-BEC Pri Tank Stress Seismic Only Mu=0.xls, Stress Max

Figure 16 BES-BEC Primary Tank Stresses, Shell Bottom, Seismic Load Only

AY Primary Tank, Best Estimate Soil, Horizontal and Vertical Seismic Input, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, Mu=0.0

		Shell Bottom Surface (outside - away from waste)					
M&D Starting M&D Element No.	Path (in.)	AY-NL-BES-BEC Hoop Stress Seismic Only (LBS/in^2) Bot, Mu=0.0	AY-NL-BES-BEC Meridional Stress Seismic Only (LBS/in^2) Bot, Mu=0.0	AY-NL-BES-BEC Stress Seismic Only Intensity (LBS/in^2) Bot, Mu=0.0	AY-NL-BES-BEC In-Plane Shear Stress Seismic Only (LBS/in^2) Bot, Mu=0.0	AY-NL-BES-BEC In-Plane Shear Force Stress Seismic Only (LBS/in^2) Bot, Mu=0.0	AY-NL-BES-BEC Thru-Thickness Shear Stress Seismic Only (LBS/in^2) Bot, Mu=0.0
762	67.33	1184.03	1076.39	1075.69	221.46	8.56	3.47
782	105.04	934.03	1156.25	1172.22	352.06	21.46	1.36
802	136.24	1272.22	1265.97	1265.28	380.44	22.91	1.30
822	181.71	516.67	828.47	828.47	388.76	10.50	1.68
842	225.10	1616.81	1326.39	1263.19	776.88	23.94	7.39
862	273.66	812.57	543.75	1556.94	1348.49	12.65	5.77
882	323.27	3165.97	1608.08	2059.03	1472.84	34.69	15.60
902	369.20	1355.42	534.79	1722.22	1289.37	26.80	7.43
922	419.20	2415.00	2045.14	2976.39	2086.73	52.17	6.91
942	444.11	2192.36	1748.40	3128.47	2447.16	251.57	9.60
962	471.06	6909.72	455.46	6809.72	2504.16	17.60	9.29
982	503.51	4697.22	660.80	4579.86	2679.35	89.18	8.64
1002	527.76	4153.47	2788.56	3370.83	2670.95	38.22	2.38
1022	554.76	3900.00	612.36	3639.24	1722.31	33.60	1.71
1042	582.26	5820.90	1323.27	5470.14	1461.85	23.17	1.30
1062	609.26	7034.93	1006.18	6052.08	1231.17	19.22	1.48
1082	636.26	8428.75	1412.01	7200.69	1048.62	12.04	1.45
1102	663.26	9160.42	1131.18	8281.94	855.67	16.46	1.48
1122	688.61	10713.89	1577.64	9436.11	874.84	32.68	1.44
1142	711.96	11024.31	1403.54	9961.11	1204.33	39.08	1.45
1162	734.96	11348.61	1221.11	10304.17	1204.33	45.33	1.39
1182	757.91	11240.97	2013.54	10790.28	1548.33	38.42	1.38
1202	782.81	7289.58	1024.31	8150.00	1281.34	9.16	2.64
1222	809.76	7347.92	748.40	6786.81	1623.76	14.38	1.95
1242	836.76	7368.06	469.72	7058.33	1950.04	12.79	1.77
1262	863.76	7527.78	1332.64	7388.89	2291.10	15.29	0.98
1282	889.76	7208.33	3194.44	7201.39	2551.24	51.20	4.04
1302	906.85	2740.97	5277.78	4680.56	2138.93	101.61	23.08
1322	916.04	4638.19	5419.44	3916.67	2149.86	246.32	27.75
1342	934.63	4765.97	5224.31	4263.89	1963.89	6.17	79.57
1362	974.63	2465.97	1839.58	3570.14	2958.47	2.09	26.51
1382	1040.78	2154.03	698.73	3004.86	1870.69	1.26	16.10
1402	1110.53	1123.02	1168.06	931.94	906.04	1.79	56.84

Figure 17 BES-BEC J-Bolt Forces, Gravity Load Only

AY Primary Tank, Best Estimate Soil, Mu=0.0, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, Gravity Only

ANSYS MAXIMUMS BY RADIUS

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included min	max	Average Bolts per Element	Min Axial Force (kip) BES-BEC Mu=0.0 Seismic	Max Axial Force (kip) BES-BEC Mu=0.0 Seismic	Shear Force1 (kip) BES-BEC Mu=0.0	Maximum Shear Force1 Model Angle	Shear Force2 (kip) BES-BEC Mu=0.0 Seismic	Maximum Shear Force2 Model Angle	Total Shear (kip) BES-BEC Mu=0.0
Radius 2	44.72	22.36	67.29	0.55	-0.016	-0.012	0.007	45	0.132	90	0.132
Radius 3	89.87	67.29	104.93	0.89	-0.019	-0.017	0.006	45	0.020	135	0.021
Radius 4	120.00	104.93	135.98	1.03	0.002	0.002	0.005	27	0.026	90	0.026
Radius 5	151.97	135.98	181.01	1.97	-0.009	-0.007	0.010	27	0.144	90	0.144
Radius 6	210.05	181.01	223.79	2.41	0.011	0.012	0.018	144	0.403	81	0.403
Radius 7	237.53	223.79	270.98	3.30	0.035	0.038	0.016	144	0.502	45	0.502
Radius 8	304.43	270.98	318.74	4.04	0.042	0.045	0.004	153	0.731	45	0.731
Radius 9	333.05	318.74	361.64	4.37	0.090	0.090	0.001	153	0.731	45	0.731
Radius 10	390.22	361.64	406.24	5.36	0.061	0.061	0.001	63	0.920	180	0.920
Radius 11	422.26	406.24	431.63	3.60	0.112	0.117	0.001	63	1.440	180	1.440

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included min	max	Average Bolts per Element	Bolt Angle (Rad)	Shear Stiffness (kip/ft)	Axial Stiffness (kip/ft)	Shear Displacement BES-BEC-Mu=0.0 Seismic	Axial Min Displacement BES-BEC-Mu=0.0 Seismic	Axial Max Displacement BES-BEC-Mu=0.0 Seismic
Radius 2	44.72	22.36	67.29	0.55	0.0351	1667	2222	0.00095	-0.00009	-0.00006
Radius 3	89.87	67.29	104.93	0.89	0.0715	1670	2219	0.00015	-0.00010	-0.00009
Radius 4	120.00	104.93	135.98	1.03	0.0968	1673	2215	0.00018	0.00001	0.00001
Radius 5	151.97	135.98	181.01	1.97	0.1252	1677	2207	0.00103	-0.00005	-0.00004
Radius 6	210.05	181.01	223.79	2.41	0.1825	1688	2192	0.00286	0.00006	0.00006
Radius 7	237.53	223.79	270.98	3.30	0.2136	1696	2172	0.00355	0.00020	0.00021
Radius 8	304.43	270.98	318.74	4.04	0.3076	1725	2132	0.00509	0.00024	0.00025
Radius 9	333.05	318.74	361.64	4.37	0.3613	1746	2086	0.00502	0.00052	0.00052
Radius 10	390.22	361.64	406.24	5.36	0.5235	1821	2006	0.00606	0.00036	0.00037
Radius 11	422.26	406.24	431.63	3.60	0.6938	1913	1933	0.00903	0.00069	0.00073

Figure 18 BES-BEC J-Bolt Forces, Gravity Plus Seismic Load

AY Primary Tank, Best Estimate Soil, Horizontal and Vertical Seismic Input, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG, Dome Friction =0.0

ANSYS MAXIMUMS BY RADIUS

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included min	Radius of J-Bolts Included max	Average Bolts per Element	Min Axial Force (kip) BES-BEC Mu=0.0	Max Axial Force (kip) BES-BEC Mu=0.0	Shear Force1 (kip) BES-BEC Mu=0.0	Maximum Shear Force1 Model Angle	Shear Force2 (kip) BES-BEC Mu=0.0	Maximum Shear Force2 Model Angle	Total Shear (kip) BES-BEC Mu=0.0
Radius 2	44.72	22.36	67.29	0.55	-0.147	0.010	0.283	81	0.449	180	0.476
Radius 3	89.87	67.29	104.93	0.89	-0.064	0.000	0.251	81	0.385	180	0.426
Radius 4	120.00	104.93	135.98	1.03	-0.070	0.043	0.286	81	0.490	0	0.490
Radius 5	151.97	135.98	181.01	1.97	-0.057	0.026	0.354	90	0.645	180	0.645
Radius 6	210.05	181.01	223.79	2.41	-0.023	0.038	0.554	90	0.844	0	0.847
Radius 7	237.53	223.79	270.98	3.30	-0.024	0.114	0.732	90	0.950	0	0.990
Radius 8	304.43	270.98	318.74	4.04	-0.024	0.098	1.343	90	1.250	0	1.602
Radius 9	333.05	318.74	361.64	4.37	-0.085	0.400	1.762	90	1.499	0	1.997
Radius 10	390.22	361.64	406.24	5.36	-0.572	0.587	2.945	90	1.684	180	3.128
Radius 11	422.26	406.24	431.63	3.60	-1.734	2.176	4.211	90	3.320	0	4.591

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included min	Radius of J-Bolts Included max	Average Bolts per Element	Bolt Angle (Rad)	Shear Stiffness (kip/ft)	Axial Stiffness (kip/ft)	BES-BEC Mu=0.0-Seismic Only	BES-BEC Mu=0.0-Seismic Only	BES-BEC Mu=0.0-Seismic Only
Radius 2	44.72	22.36	67.29	0.55	0.0351	1667	2222	0.00342	-0.00079	0.00005
Radius 3	89.87	67.29	104.93	0.89	0.0715	1670	2219	0.00306	-0.00035	0.00000
Radius 4	120.00	104.93	135.98	1.03	0.0968	1673	2215	0.00351	-0.00038	0.00023
Radius 5	151.97	135.98	181.01	1.97	0.1252	1677	2207	0.00461	-0.00031	0.00014
Radius 6	210.05	181.01	223.79	2.41	0.1825	1688	2192	0.00602	-0.00013	0.00021
Radius 7	237.53	223.79	270.98	3.30	0.2136	1696	2172	0.00700	-0.00013	0.00063
Radius 8	304.43	270.98	318.74	4.04	0.3076	1725	2132	0.01114	-0.00014	0.00055
Radius 9	333.05	318.74	361.64	4.37	0.3613	1746	2086	0.01372	-0.00049	0.00230
Radius 10	390.22	361.64	406.24	5.36	0.5235	1821	2006	0.02061	-0.00342	0.00351
Radius 11	422.26	406.24	431.63	3.60	0.6938	1913	1933	0.02879	-0.01077	0.01351

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Figure 19 BES-BEC J-Bolt Forces, Seismic Load Only

AY Primary Tank, Best Estimate Soil, Horizontal and Vertical Seismic Input, Best Estimate Tank Concrete, 422 in. Waste Level at 1.7 SpG Seismic Only Mu=0.0

ANSYS MAXIMUMS BY RADIUS

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included min	Radius of J-Bolts Included max	Average Bolts per Element	Min Axial Force (kip) BES-BEC-Seismic Only Mu=0.0	Max Axial Force (kip) BES-BEC-Seismic Only Mu=0.0	Shear Force1 (kip) BES-BEC-Seismic Only Mu=0.0	Maximum Shear Force1 Model Angle	Shear Force2 (kip) BES-BEC-Seismic Only Mu=0.0	Maximum Shear Force2 Model Angle	Total Shear (kip) BES-BEC-Seismic Only Mu=0.0
Radius 2	44.72	22.36	67.29	0.55	-0.131	0.022	0.276	108	0.317	0	0.420
Radius 3	89.87	67.29	104.93	0.89	-0.046	0.017	0.245	108	0.364	0	0.439
Radius 4	120.00	104.93	135.98	1.03	-0.071	0.040	0.281	108	0.464	0	0.542
Radius 5	151.97	135.98	181.01	1.97	-0.048	0.033	0.343	108	0.501	0	0.607
Radius 6	210.05	181.01	223.79	2.41	-0.034	0.026	0.536	108	0.442	144	0.695
Radius 7	237.53	223.79	270.98	3.30	-0.060	0.077	0.716	90	0.449	135	0.845
Radius 8	304.43	270.98	318.74	4.04	-0.067	0.053	1.339	117	0.519	117	1.436
Radius 9	333.05	318.74	361.64	4.37	-0.175	0.309	1.761	117	0.768	117	1.921
Radius 10	390.22	361.64	406.24	5.36	-0.632	0.526	2.943	108	0.764	0	3.041
Radius 11	422.26	406.24	431.63	3.60	-1.846	2.059	4.210	108	1.880	0	4.610

M&D J-Bolt Radius No.	Mean J-Bolt Radius	Radius of J-Bolts Included min	Radius of J-Bolts Included max	Average Bolts per Element	Bolt Angle (Rad)	Shear Stiffness (kip/ft)	Axial Stiffness (kip/ft)	BES-BEC-Seismic Only Mu=0.0	BES-BEC-Seismic Only Mu=0.0	BES-BEC-Seismic Only Mu=0.0
Radius 2	44.72	22.36	67.29	0.55	0.0351	1667	2222	0.00302	-0.00071	0.00012
Radius 3	89.87	67.29	104.93	0.89	0.0715	1670	2219	0.00316	-0.00025	0.00009
Radius 4	120.00	104.93	135.98	1.03	0.0968	1673	2215	0.00389	-0.00039	0.00022
Radius 5	151.97	135.98	181.01	1.97	0.1252	1677	2207	0.00435	-0.00026	0.00018
Radius 6	210.05	181.01	223.79	2.41	0.1825	1688	2192	0.00494	-0.00019	0.00014
Radius 7	237.53	223.79	270.98	3.30	0.2136	1696	2172	0.00598	-0.00033	0.00042
Radius 8	304.43	270.98	318.74	4.04	0.3076	1725	2132	0.00999	-0.00038	0.00030
Radius 9	333.05	318.74	361.64	4.37	0.3613	1746	2086	0.01321	-0.00100	0.00178
Radius 10	390.22	361.64	406.24	5.36	0.5235	1821	2006	0.02003	-0.00378	0.00314
Radius 11	422.26	406.24	431.63	3.60	0.6938	1913	1933	0.02891	-0.01146	0.01278

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AY-2D-NL-BES-BEC J Bolt Forces Seismic Mu=0.xls
Page 1

Figure 20 BES-BEC Primary Tank/Concrete Dome Contact Forces, Gravity Load Only

Tank AY, 422 Inch Waste Level
SpG = 1.7
Best Estimate Soil
Best Estimate Concrete

Radius	Max Pressure Primary Tank/Concrete Tank Dome AY Mu=0.0 Gravity Only (PSI)	Min Pressure Primary Tank/Concrete Tank Dome AY Mu=0.0 Gravity Only (PSI)	Max Gap Lateral Displacement Primary Tank /Concrete Tank Dome Mu=0.0 Gravity Only (in)	Max Gap Displacement Primary Tank/Concete Tank Dome AY Mu=0.0 Gravity Only (Inches)	Max Sliding Friction Primary Tank/Concete Tank Dome AY Mu=0.0 Gravity Only (Inches)
67.727	1.467	1.404	0.002178	0.000000	0.001467
105.668	1.096	1.073	0.003186	0.000000	0.001096
137.069	0.687	0.677	0.003570	0.000000	0.000687
182.849	0.865	0.849	0.004493	0.000000	0.000865
226.563	0.914	0.880	0.002713	-0.000010	0.000914
275.566	0.594	0.586	0.003156	-0.000020	0.000594
325.690	1.228	1.218	0.003839	-0.000061	0.001228
372.305	0.332	0.328	0.004414	-0.000085	0.000332
423.427	0.769	0.763	0.005597	-1.054320	0.000769

Figure 21 BES-BEC Primary Tank/Concrete Dome Contact Forces, Gravity Plus Seismic Load

Tank AY, 422 Inch Waste Level
SpG = 1.7
Best Estimate Soil
Best Estimate Concrete

Radius	Max Pressure Primary Tank/Concrete Tank Dome AY Seismic (PSI) Mu=0.0	Min Pressure Primary Tank/Concrete Tank Dome AY Seismic (PSI) Mu=0.0	Max Gap Lateral Displacement Primary Tank /Concrete Tank Dome Seismic (in) Mu=0.0	Max Gap Displacement Primary Tank/Concete Tank Dome AY Seismic (Inches) Mu=0.0	Max Gap Friction Primary Tank/Concete Tank Dome AY Seismic (Inches) Mu=0.0
67.727	7.465	0.731	0.003374	0.000000	0.007465
105.668	4.324	0.603	0.004213	-0.000075	0.003932
137.069	3.524	0.145	0.005490	-0.000076	0.003459
182.849	2.197	0.501	0.005758	-0.000011	0.002197
226.563	2.401	0.457	0.009658	-0.000098	0.002401
275.566	1.553	0.287	0.008815	-0.000142	0.001553
325.690	3.663	0.000	0.011111	-0.000633	0.003663
372.305	14.250	0.000	0.029136	-0.001382	0.014250
423.427	5.424	0.000	0.012732	-1.059720	0.005424

Figure 22 BES-BEC Primary Tank/Concrete Dome Contact Forces, Seismic Load Only

Tank AY, 422 Inch Waste Level
SpG = 1.7
Best Estimate Soil
Best Estimate Concrete

Radius	Max Pressure Primary Tank/Concrete Tank Dome AY Seismic Only (PSI) Mu=0.0	Min Pressure Primary Tank/Concrete Tank Dome AY Seismic Only (PSI) Mu=0.0	Max Gap Lateral Displacement Primary Tank /Concrete Tank Dome Seismic Only (in) Mu=0.0	Max Gap Displacement Primary Tank/Concete Tank Dome AY Seismic Only (Inches) Mu=0.0	Max Gap Displacement Primary Tank/Concete Tank Dome AY Seismic Only (Inches) Mu=0.0
67.727	5.999	-0.673	0.001196	0.000000	0.005999
105.668	3.228	-0.470	0.001027	-0.000075	0.002836
137.069	2.837	-0.531	0.001920	-0.000076	0.002772
182.849	1.333	-0.348	0.001265	-0.000011	0.001333
226.563	1.488	-0.423	0.006944	-0.000088	0.001488
275.566	0.959	-0.299	0.005659	-0.000122	0.000959
325.690	2.435	-1.218	0.007272	-0.000572	0.002435
372.305	13.918	-0.328	0.024722	-0.001298	0.013918
423.427	4.656	-0.763	0.007135	-0.005400	0.004656

BES-BEC, μ=0.0 Seismic File Listing

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 Volume Serial Number is 8785-3B22

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04/30/2006  03:19 PM             3,781 J-Bolt-Cont_117max.OUT
04/30/2006  03:19 PM         1,609,038 J-Bolt-Cont_117th.OUT
04/30/2006  03:23 PM             3,781 J-Bolt-Cont_126max.OUT
04/30/2006  03:23 PM         1,609,038 J-Bolt-Cont_126th.OUT
04/30/2006  03:27 PM             3,781 J-Bolt-Cont_135max.OUT
04/30/2006  03:27 PM         1,609,038 J-Bolt-Cont_135th.OUT
04/30/2006  03:31 PM             3,781 J-Bolt-Cont_144max.OUT
04/30/2006  03:31 PM         1,609,038 J-Bolt-Cont_144th.OUT
04/30/2006  03:35 PM             3,781 J-Bolt-Cont_153max.OUT
04/30/2006  03:35 PM         1,609,038 J-Bolt-Cont_153th.OUT
04/30/2006  03:40 PM             3,781 J-Bolt-Cont_162max.OUT
04/30/2006  03:40 PM         1,609,038 J-Bolt-Cont_162th.OUT
04/30/2006  03:44 PM             3,781 J-Bolt-Cont_171max.OUT
04/30/2006  03:44 PM         1,609,038 J-Bolt-Cont_171th.OUT
04/30/2006  03:48 PM             3,781 J-Bolt-Cont_180max.OUT
04/30/2006  03:48 PM         1,609,038 J-Bolt-Cont_180th.OUT
04/30/2006  02:34 PM             3,781 J-Bolt-Cont_18max.OUT
04/30/2006  02:34 PM         1,609,038 J-Bolt-Cont_18th.OUT
04/30/2006  02:38 PM             3,781 J-Bolt-Cont_27max.OUT
04/30/2006  02:38 PM         1,609,038 J-Bolt-Cont_27th.OUT
04/30/2006  02:42 PM             3,781 J-Bolt-Cont_36max.OUT
04/30/2006  02:42 PM         1,609,038 J-Bolt-Cont_36th.OUT
04/30/2006  02:46 PM             3,781 J-Bolt-Cont_45max.OUT
04/30/2006  02:46 PM         1,609,038 J-Bolt-Cont_45th.OUT
04/30/2006  02:50 PM             3,781 J-Bolt-Cont_54max.OUT
04/30/2006  02:50 PM         1,609,038 J-Bolt-Cont_54th.OUT
04/30/2006  02:54 PM             3,781 J-Bolt-Cont_63max.OUT
04/30/2006  02:54 PM         1,609,038 J-Bolt-Cont_63th.OUT
04/30/2006  02:58 PM             3,781 J-Bolt-Cont_72max.OUT
04/30/2006  02:58 PM         1,609,038 J-Bolt-Cont_72th.OUT
04/30/2006  03:02 PM             3,781 J-Bolt-Cont_81max.OUT
04/30/2006  03:02 PM         1,609,038 J-Bolt-Cont_81th.OUT
04/30/2006  03:07 PM             3,781 J-Bolt-Cont_90max.OUT
04/30/2006  03:07 PM         1,609,038 J-Bolt-Cont_90th.OUT
04/30/2006  03:11 PM             3,781 J-Bolt-Cont_99max.OUT
04/30/2006  03:11 PM         1,609,038 J-Bolt-Cont_99th.OUT
04/30/2006  02:30 PM             3,781 J-Bolt-Cont_9max.OUT
04/30/2006  02:30 PM         1,609,166 J-Bolt-Cont_9th.OUT
06/01/2005  02:17 PM             1,708 Liner.txt
05/02/2005  03:19 PM               667 live_load.txt
11/11/2005  11:38 AM             6,185 Near-Soil-1.txt
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04/20/2005  02:14 PM             508 outer-spar.txt
10/31/2005  01:18 PM           5,549 Primary-Props-AY.txt
09/27/2005  04:52 PM           1,538 Primary.txt
04/28/2006  02:15 PM         342,045 QA.out
10/31/2005  11:31 AM           1,108 RS_FREQ.txt
05/01/2006  09:12 AM       3,239,879 Run-Tank-Out.out
04/28/2006  02:10 PM           1,968 Run-Tank.txt
02/11/2005  02:22 PM           1,053 Slave.txt
11/11/2005  11:36 AM           4,989 Soil-Prop-Mean-Geo.txt
04/27/2006  02:15 PM           1,924 Solve-Gravity-BES.txt
04/28/2006  02:13 PM           1,913 Solve-TH-BES.txt
10/31/2005  12:02 PM           3,363 spectra-conc-0.txt
10/14/2005  12:18 PM           2,061 spectra-concrete.txt
10/31/2005  11:17 AM           3,551 spectra-primary-180.txt
09/06/2005  07:49 AM           1,287 spectra-soil.txt
06/20/2005  10:04 AM             647 spectra-wall.txt
06/20/2005  09:52 AM             679 spectra-waste.txt
12/09/2005  09:04 AM         345,088 str-comp_0-90b.xls
12/09/2005  09:04 AM         345,600 str-comp_0-90m.xls
12/09/2005  09:05 AM         343,552 str-comp_0-90t.xls
12/09/2005  09:05 AM         345,088 str-comp_99-180b.xls
12/09/2005  09:05 AM         345,088 str-comp_99-180m.xls
12/09/2005  09:05 AM         343,552 str-comp_99-180t.xls
05/02/2006  07:55 AM         345,088 str-primary_0-90b.xls
05/02/2006  07:55 AM         345,600 str-primary_0-90m.xls
05/02/2006  07:55 AM         343,552 str-primary_0-90t.xls
05/02/2006  07:56 AM         345,088 str-primary_99-180b.xls
05/02/2006  07:56 AM         345,088 str-primary_99-180m.xls
05/02/2006  07:56 AM         343,552 str-primary_99-180t.xls
01/05/2006  04:12 PM             566 strain-compb-p.txt
01/05/2006  04:11 PM             566 strain-compb.txt
01/05/2006  04:13 PM             566 strain-compm-p.txt
09/02/2005  09:51 AM             705 strain-compm.txt
01/05/2006  04:14 PM             578 strain-compt-p.txt
09/02/2005  09:50 AM             720 strain-compt.txt
01/06/2006  10:07 AM             728 Strain-Liner-floor.txt
01/05/2006  04:14 PM             550 Strain-Liner-p.txt
01/06/2006  03:45 PM             823 Strain-Liner-wall.txt
09/02/2005  09:52 AM             544 Strain-Liner.txt
01/06/2006  03:46 PM             274 Strain-Primary.txt
01/06/2006  03:48 PM             246 Strain.txt
01/06/2006  03:41 PM             554 stress-compb-p.txt
09/08/2005  11:18 AM             692 stress-compb.txt
01/06/2006  03:40 PM             554 stress-compm-p.txt
11/01/2005  11:46 AM             702 stress-compm.txt
01/06/2006  03:40 PM             554 stress-compt-p.txt
09/08/2005  10:20 AM             692 stress-compt.txt
04/13/2005  08:38 AM             205 Stress-Primary.txt
05/01/2006  07:46 AM          16,291 Stress-pt_108max-b.OUT
05/01/2006  04:11 AM          16,291 Stress-pt_108max-m.OUT
05/01/2006  12:36 AM          16,210 Stress-pt_108max-t.OUT
05/01/2006  07:46 AM       6,850,602 Stress-pt_108th-b.OUT
05/01/2006  04:11 AM       6,850,602 Stress-pt_108th-m.OUT
05/01/2006  12:36 AM       6,821,874 Stress-pt_108th-t.OUT
05/01/2006  07:57 AM          16,291 Stress-pt_117max-b.OUT
05/01/2006  04:22 AM          16,291 Stress-pt_117max-m.OUT
05/01/2006  12:46 AM          16,210 Stress-pt_117max-t.OUT
05/01/2006  07:57 AM       6,850,602 Stress-pt_117th-b.OUT
05/01/2006  04:22 AM       6,850,602 Stress-pt_117th-m.OUT
05/01/2006  12:46 AM       6,821,874 Stress-pt_117th-t.OUT
05/01/2006  08:08 AM          16,291 Stress-pt_126max-b.OUT
05/01/2006  04:33 AM          16,291 Stress-pt_126max-m.OUT
05/01/2006  12:57 AM          16,210 Stress-pt_126max-t.OUT
05/01/2006  08:08 AM       6,850,602 Stress-pt_126th-b.OUT
05/01/2006  04:33 AM       6,850,602 Stress-pt_126th-m.OUT
05/01/2006  12:57 AM       6,821,874 Stress-pt_126th-t.OUT
05/01/2006  08:18 AM          16,291 Stress-pt_135max-b.OUT
05/01/2006  04:43 AM          16,291 Stress-pt_135max-m.OUT
05/01/2006  01:08 AM          16,210 Stress-pt_135max-t.OUT
05/01/2006  08:18 AM       6,850,602 Stress-pt_135th-b.OUT
05/01/2006  04:44 AM       6,850,602 Stress-pt_135th-m.OUT
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05/01/2006  01:08 AM         6,821,874 Stress-pt_135th-t.OUT
05/01/2006  08:29 AM            16,291 Stress-pt_144max-b.OUT
05/01/2006  04:54 AM            16,291 Stress-pt_144max-m.OUT
05/01/2006  01:19 AM            16,210 Stress-pt_144max-t.OUT
05/01/2006  08:29 AM         6,850,602 Stress-pt_144th-b.OUT
05/01/2006  04:54 AM         6,850,602 Stress-pt_144th-m.OUT
05/01/2006  01:19 AM         6,821,874 Stress-pt_144th-t.OUT
05/01/2006  08:40 AM            16,291 Stress-pt_153max-b.OUT
05/01/2006  05:05 AM            16,291 Stress-pt_153max-m.OUT
05/01/2006  01:29 AM            16,210 Stress-pt_153max-t.OUT
05/01/2006  08:40 AM         6,850,602 Stress-pt_153th-b.OUT
05/01/2006  05:05 AM         6,850,602 Stress-pt_153th-m.OUT
05/01/2006  01:30 AM         6,821,874 Stress-pt_153th-t.OUT
05/01/2006  08:50 AM            16,291 Stress-pt_162max-b.OUT
05/01/2006  05:16 AM            16,291 Stress-pt_162max-m.OUT
05/01/2006  01:40 AM            16,210 Stress-pt_162max-t.OUT
05/01/2006  08:50 AM         6,850,602 Stress-pt_162th-b.OUT
05/01/2006  05:16 AM         6,850,602 Stress-pt_162th-m.OUT
05/01/2006  01:40 AM         6,821,874 Stress-pt_162th-t.OUT
05/01/2006  09:01 AM            16,295 Stress-pt_171max-b.OUT
05/01/2006  05:26 AM            16,295 Stress-pt_171max-m.OUT
05/01/2006  01:51 AM            16,214 Stress-pt_171max-t.OUT
05/01/2006  09:01 AM         6,850,602 Stress-pt_171th-b.OUT
05/01/2006  05:26 AM         6,850,602 Stress-pt_171th-m.OUT
05/01/2006  01:51 AM         6,821,874 Stress-pt_171th-t.OUT
05/01/2006  09:12 AM            16,295 Stress-pt_180max-b.OUT
05/01/2006  05:37 AM            16,295 Stress-pt_180max-m.OUT
05/01/2006  02:02 AM            16,214 Stress-pt_180max-t.OUT
05/01/2006  09:12 AM         6,850,602 Stress-pt_180th-b.OUT
05/01/2006  05:37 AM         6,850,602 Stress-pt_180th-m.OUT
05/01/2006  02:02 AM         6,821,874 Stress-pt_180th-t.OUT
05/01/2006  05:59 AM            16,291 Stress-pt_18max-b.OUT
05/01/2006  02:23 AM            16,291 Stress-pt_18max-m.OUT
04/30/2006  10:48 PM            16,210 Stress-pt_18max-t.OUT
05/01/2006  05:59 AM         6,850,602 Stress-pt_18th-b.OUT
05/01/2006  02:23 AM         6,850,602 Stress-pt_18th-m.OUT
04/30/2006  10:48 PM         6,821,874 Stress-pt_18th-t.OUT
05/01/2006  06:09 AM            16,291 Stress-pt_27max-b.OUT
05/01/2006  02:34 AM            16,291 Stress-pt_27max-m.OUT
04/30/2006  10:59 PM            16,210 Stress-pt_27max-t.OUT
05/01/2006  06:09 AM         6,850,602 Stress-pt_27th-b.OUT
05/01/2006  02:34 AM         6,850,602 Stress-pt_27th-m.OUT
04/30/2006  10:59 PM         6,821,874 Stress-pt_27th-t.OUT
05/01/2006  06:20 AM            16,291 Stress-pt_36max-b.OUT
05/01/2006  02:45 AM            16,291 Stress-pt_36max-m.OUT
04/30/2006  11:10 PM            16,210 Stress-pt_36max-t.OUT
05/01/2006  06:20 AM         6,850,602 Stress-pt_36th-b.OUT
05/01/2006  02:45 AM         6,850,602 Stress-pt_36th-m.OUT
04/30/2006  11:10 PM         6,821,874 Stress-pt_36th-t.OUT
05/01/2006  06:31 AM            16,291 Stress-pt_45max-b.OUT
05/01/2006  02:56 AM            16,291 Stress-pt_45max-m.OUT
04/30/2006  11:20 PM            16,210 Stress-pt_45max-t.OUT
05/01/2006  06:31 AM         6,850,602 Stress-pt_45th-b.OUT
05/01/2006  02:56 AM         6,850,602 Stress-pt_45th-m.OUT
04/30/2006  11:20 PM         6,821,874 Stress-pt_45th-t.OUT
05/01/2006  06:41 AM            16,291 Stress-pt_54max-b.OUT
05/01/2006  03:06 AM            16,291 Stress-pt_54max-m.OUT
04/30/2006  11:31 PM            16,210 Stress-pt_54max-t.OUT
05/01/2006  06:41 AM         6,850,602 Stress-pt_54th-b.OUT
05/01/2006  03:06 AM         6,850,602 Stress-pt_54th-m.OUT
04/30/2006  11:31 PM         6,821,874 Stress-pt_54th-t.OUT
05/01/2006  06:52 AM            16,291 Stress-pt_63max-b.OUT
05/01/2006  03:17 AM            16,291 Stress-pt_63max-m.OUT
04/30/2006  11:42 PM            16,210 Stress-pt_63max-t.OUT
05/01/2006  06:52 AM         6,850,602 Stress-pt_63th-b.OUT
05/01/2006  03:17 AM         6,850,602 Stress-pt_63th-m.OUT
04/30/2006  11:42 PM         6,821,874 Stress-pt_63th-t.OUT
05/01/2006  07:03 AM            16,291 Stress-pt_72max-b.OUT
05/01/2006  03:28 AM            16,291 Stress-pt_72max-m.OUT
04/30/2006  11:52 PM            16,210 Stress-pt_72max-t.OUT
05/01/2006  07:03 AM         6,850,602 Stress-pt_72th-b.OUT
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05/01/2006  03:28 AM         6,850,602 Stress-pt_72th-m.OUT
04/30/2006  11:52 PM         6,821,874 Stress-pt_72th-t.OUT
05/01/2006  07:13 AM            16,291 Stress-pt_81max-b.OUT
05/01/2006  03:38 AM            16,291 Stress-pt_81max-m.OUT
05/01/2006  12:03 AM            16,210 Stress-pt_81max-t.OUT
05/01/2006  07:13 AM         6,850,602 Stress-pt_81th-b.OUT
05/01/2006  03:38 AM         6,850,602 Stress-pt_81th-m.OUT
05/01/2006  12:03 AM         6,821,874 Stress-pt_81th-t.OUT
05/01/2006  07:24 AM            16,291 Stress-pt_90max-b.OUT
05/01/2006  03:49 AM            16,291 Stress-pt_90max-m.OUT
05/01/2006  12:14 AM            16,210 Stress-pt_90max-t.OUT
05/01/2006  07:24 AM         6,850,602 Stress-pt_90th-b.OUT
05/01/2006  03:49 AM         6,850,602 Stress-pt_90th-m.OUT
05/01/2006  12:14 AM         6,821,874 Stress-pt_90th-t.OUT
05/01/2006  07:35 AM            16,291 Stress-pt_99max-b.OUT
05/01/2006  04:00 AM            16,291 Stress-pt_99max-m.OUT
05/01/2006  12:25 AM            16,210 Stress-pt_99max-t.OUT
05/01/2006  07:35 AM         6,850,602 Stress-pt_99th-b.OUT
05/01/2006  04:00 AM         6,850,602 Stress-pt_99th-m.OUT
05/01/2006  12:25 AM         6,821,874 Stress-pt_99th-t.OUT
05/01/2006  05:48 AM            16,291 Stress-pt_9max-b.OUT
05/01/2006  02:13 AM            16,291 Stress-pt_9max-m.OUT
04/30/2006  10:37 PM            16,210 Stress-pt_9max-t.OUT
05/01/2006  05:48 AM         6,850,730 Stress-pt_9th-b.OUT
05/01/2006  02:13 AM         6,850,730 Stress-pt_9th-m.OUT
04/30/2006  10:37 PM         6,822,002 Stress-pt_9th-t.OUT
10/31/2005  01:13 PM             3,825 Tank-Coordinates-AY.txt
05/25/2005  04:32 PM             2,512 Tank-Mesh1.txt
04/28/2006  02:15 PM               102 tank-out.out
02/25/2005  03:24 PM             5,406 Tank-Props-BEC-250.txt
04/28/2006  02:15 PM             4,694 Tank-th.out
12/22/2005  01:43 PM            10,035 temp.log
05/16/2005  04:40 PM            41,470 TH-266-Mean-Geo-V.txt
05/13/2005  11:57 AM            41,472 TH-266-Mean-Geo.txt
11/01/2005  01:19 PM               342 Waste-Reaction.txt
10/31/2005  01:01 PM             3,265 Waste-solid-AY.txt
04/24/2006  11:35 AM               240 Zero-Friction.log
             380 File(s) 39,768,827,504 bytes

 Directory of C:\Users\Bruce\2008-000 PNNL\2008-006 J-Bolts\BES-BEC-Seismic\BES-BEC-
Gravity

07/17/2006  03:14 PM    <DIR>          .
07/17/2006  03:14 PM    <DIR>          ..
04/28/2006  02:15 PM               100 All-Forces.txt
05/02/2006  02:09 PM         3,185,152 AY-2D-NL-BES-BEC Conc Tank Demand Gravity
Mu=0.0.xls
05/02/2006  02:08 PM           692,224 AY-2D-NL-BES-BEC J Bolt Forces Gravity  Mu=0.0.xls
05/03/2006  07:58 AM         8,429,056 AY-2D-NL-BES-BEC Pri Tank Stress Gravity
Mu=0.0.xls
05/26/2006  09:25 AM           886,784 AY-2D-NL-BES-BEC-J-Bolt-Contact-Gravity Mu=0.0-
L.xls
05/02/2006  02:06 PM            87,502 BEC-BES-Gravity-Dome-F-000-L.out
05/02/2006  01:44 PM               136 BES-BEC-Gravity.err
05/02/2006  01:44 PM               480 BES-BEC-Gravity.log
05/02/2006  02:06 PM             2,998 BES-BEC-No-Dome-Friction-Gravity.BCS
05/02/2006  02:07 PM        35,717,120 BES-BEC-No-Dome-Friction-Gravity.db
05/02/2006  02:06 PM        55,508,992 BES-BEC-No-Dome-Friction-Gravity.dbb
05/02/2006  02:06 PM        12,386,304 BES-BEC-No-Dome-Friction-Gravity.emat
07/17/2006  03:13 PM            80,706 BES-BEC-No-Dome-Friction-Gravity.err
05/02/2006  02:06 PM       102,563,840 BES-BEC-No-Dome-Friction-Gravity.esav
05/02/2006  02:06 PM        27,852,800 BES-BEC-No-Dome-Friction-Gravity.full
05/02/2006  02:05 PM         1,605,361 BES-BEC-No-Dome-Friction-Gravity.ldhi
07/17/2006  03:14 PM             6,846 BES-BEC-No-Dome-Friction-Gravity.log
05/02/2006  02:06 PM             2,295 BES-BEC-No-Dome-Friction-Gravity.mntr
05/02/2006  02:05 PM       102,563,840 BES-BEC-No-Dome-Friction-Gravity.osav
05/02/2006  02:06 PM             1,699 BES-BEC-No-Dome-Friction-Gravity.PVTS
05/02/2006  02:06 PM       103,546,880 BES-BEC-No-Dome-Friction-Gravity.r001
05/02/2006  01:45 PM        35,782,656 BES-BEC-No-Dome-Friction-Gravity.rdb
05/02/2006  02:06 PM       207,421,440 BES-BEC-No-Dome-Friction-Gravity.rst
04/28/2006  02:15 PM                78 BES-BEC-No-Dome-Friction.log
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04/28/2006  09:57 AM             5,790 Bolts-Friction.txt
06/09/2005  02:59 PM               262 Boundary.txt
04/25/2006  02:02 PM               195 Contact-AY.txt
12/01/2005  10:11 AM               586 Contact-Footing.txt
09/02/2005  10:28 AM               604 Contact-Insul.txt
04/28/2006  02:15 PM               655 Contact-J-Bolts.txt
09/09/2005  10:59 AM               608 Contact-Primary.txt
09/15/2005  12:50 PM               742 Contact-Soil.txt
09/06/2005  12:16 PM               630 Contact-Waste-AY.txt
01/03/2006  12:17 PM             1,616 Disp-J-Bolts.txt
09/22/2005  05:05 PM             8,608 Far-Soil.txt
04/28/2006  02:15 PM             1,140 file.log
12/20/2005  05:49 PM            39,925 file.txt
10/13/2005  07:54 AM               562 Fix-Soil.txt
04/06/2005  09:24 AM               894 Force-c.txt
05/02/2006  02:07 PM             4,996 Force-c_108amax.OUT
05/02/2006  02:07 PM            19,200 Force-c_108ath.OUT
05/02/2006  02:07 PM            14,716 Force-c_108max.OUT
05/02/2006  02:07 PM            41,040 Force-c_108th.OUT
05/02/2006  02:07 PM             4,996 Force-c_117amax.OUT
05/02/2006  02:07 PM            19,200 Force-c_117ath.OUT
05/02/2006  02:07 PM            14,716 Force-c_117max.OUT
05/02/2006  02:07 PM            41,040 Force-c_117th.OUT
05/02/2006  02:07 PM             4,996 Force-c_126amax.OUT
05/02/2006  02:07 PM            19,200 Force-c_126ath.OUT
05/02/2006  02:07 PM            14,716 Force-c_126max.OUT
05/02/2006  02:07 PM            41,040 Force-c_126th.OUT
05/02/2006  02:07 PM             4,996 Force-c_135amax.OUT
05/02/2006  02:07 PM            19,200 Force-c_135ath.OUT
05/02/2006  02:07 PM            14,716 Force-c_135max.OUT
05/02/2006  02:07 PM            41,040 Force-c_135th.OUT
05/02/2006  02:07 PM             4,996 Force-c_144amax.OUT
05/02/2006  02:07 PM            19,200 Force-c_144ath.OUT
05/02/2006  02:07 PM            14,716 Force-c_144max.OUT
05/02/2006  02:07 PM            41,040 Force-c_144th.OUT
05/02/2006  02:07 PM             4,996 Force-c_153amax.OUT
05/02/2006  02:07 PM            19,200 Force-c_153ath.OUT
05/02/2006  02:07 PM            14,716 Force-c_153max.OUT
05/02/2006  02:07 PM            41,040 Force-c_153th.OUT
05/02/2006  02:07 PM             4,996 Force-c_162amax.OUT
05/02/2006  02:07 PM            19,200 Force-c_162ath.OUT
05/02/2006  02:07 PM            14,716 Force-c_162max.OUT
05/02/2006  02:07 PM            41,040 Force-c_162th.OUT
05/02/2006  02:07 PM             4,996 Force-c_171amax.OUT
05/02/2006  02:07 PM            19,200 Force-c_171ath.OUT
05/02/2006  02:07 PM            14,716 Force-c_171max.OUT
05/02/2006  02:07 PM            41,040 Force-c_171th.OUT
05/02/2006  02:07 PM             4,996 Force-c_180amax.OUT
05/02/2006  02:07 PM            19,200 Force-c_180ath.OUT
05/02/2006  02:07 PM            14,716 Force-c_180max.OUT
05/02/2006  02:07 PM            41,040 Force-c_180th.OUT
05/02/2006  02:07 PM             4,996 Force-c_18amax.OUT
05/02/2006  02:07 PM            19,200 Force-c_18ath.OUT
05/02/2006  02:07 PM            14,716 Force-c_18max.OUT
05/02/2006  02:07 PM            41,040 Force-c_18th.OUT
05/02/2006  02:07 PM             4,996 Force-c_27amax.OUT
05/02/2006  02:07 PM            19,200 Force-c_27ath.OUT
05/02/2006  02:07 PM            14,716 Force-c_27max.OUT
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05/02/2006  02:07 PM            16,210 Stress-pt_63max-t.OUT
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Appendix D

Anchor Bolt Modeling and Evaluation

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Appendix D

Anchor Bolt Modeling and Evaluation

D.1 Introduction

Subsequent to the previous publication of this report, at a review meeting of the PNNL analyses on the Effect of Increased Liquid Level in 241-AP Tank Farms, the reviewers raised concerns with the anchor bolt evaluation. The ultimate shear capacity used in the original evaluation was judged to be unconservative. In response, the secant stiffness representation of the anchor bolts was developed and an evaluation method based on allowable displacements was identified. Complete details are given in Appendix A of the Increased Liquid Level report (Deibler et al. 2008). Because of the reviewers concerns and subsequent revisions to the anchor bolt modeling and evaluation for the 241-AP DST's, it was necessary to reflect these changes in the Baseline analyses documented in this report.

The anchor bolts are used to attach the steel primary tank in the tank dome and the steel secondary liner in the wall to the secondary concrete tank. The anchor bolts take several different forms, depending on the tank family. The AY, AZ, and SY tanks use J-bolts (or hooked bolts with 180 degree bend to use the terminology of ACI-318). The AN and AW tanks use L-bolts (hooked bolts with 90 degree bend). The AP tanks use headed studs. Because of these differences in the anchor bolts, it was not possible to directly transfer the modeling and evaluation methodology from the AP Increased Liquid Level analysis to the Baseline analyses. This appendix describes the additional considerations.

D.2 Modeling

The secant stiffness representation of the anchor bolts was developed to more accurately represent the nonlinear shear deformation of the anchor bolts that is exhibited in concrete anchorage (Oehlers and Sved, 1995 and Ollgaard et al. 1971). The secant stiffness is lower than the elastic stiffness and allows the redistribution of anchor bolt forces. The methodology described by Deibler et al. (2008) was based on detailed finite element anchor bolt modeling in conjunction with available test data.

Implementation of this method in the TOLA model required replacement of the original beam elements with a pair of spring elements – one normal to the primary tank surface for the axial stiffness and one parallel to the surface for the shear stiffness. Since the TOLA and seismic demands are calculated with separate distinct models and the results are combined by linear superposition, it was necessary to use common spring stiffnesses between the two models.

D.2.1 Development of Shear Secant Stiffness

The design specifications for the different Hanford double shell tank farms required twenty-eight day concrete strengths that range from 3 ksi to 5 ksi (Table D.1). Other factors including further aging (increasing concrete strength with time) and thermal degradation (decreasing concrete strength with increasing temperature) also affect the actual strength of the concrete surrounding the anchor bolts in the tank domes. It is also known that the shear load-displacement behavior of concrete anchors is a function of concrete compressive strength (Ollgaard et al. 1971, Oehlers and Sved 1995, and Lam and El-Lobody 2005). This variation is significant because the anchor shear stiffness is a direct input to the DST anchor evaluations. Therefore, the following discussion summarizes information from the literature to recommend bounds on the anchor secant shear stiffness and the allowable shear displacement for a range of concrete strengths that are estimated to bound the DST concrete strength.

The secant shear stiffness is the linear slope of the load deflection curve defined by either the maximum shear load divided by the corresponding shear displacement or the shear failure load divided by the corresponding shear failure displacement. Variations in anchor shear test results for different concrete strengths provide ranges of shear force and shear displacement from which to calculate the secant stiffness. Ollgaard et al. (1971), Oehlers and Sved (1995), and Lam and El-Lobody (2005) provide data and statistical curve fits that help to define the variation in shear load and shear displacement as a function of concrete strength. These data are from shear push-over tests of ¾-inch diameter headed studs that were welded directly to the flange plates of the test beams. In contrast, the Hanford DSTs use internally threaded, ¾-inch diameter welded studs with ½-inch diameter threaded-in anchors. The different tank farms used either headed studs, J-bolts, or L-bolts as shown in Table D.1. A detailed finite element model was developed to predict the shear deformation behavior of the AP configuration with the headed stud (Deibler, 2008). These results provided a means by which to scale the experimental data for ¾-inch studs to the Hanford headed-stud configuration.

Table D.1. Anchorage Configurations

Tank Farm	Concrete Design Compressive Strength (ksi)	Anchor Bolt Configuration
AN	4.5	L-bolt
AP	5	Headed stud
AW	5	L-bolt
AY	3	J-bolt
AZ	3	J-bolt
SY	4.5	J-bolt

D.2.1.1 Estimating the Equivalent Anchor Diameter that Approximates the Shear Capacity of the AP Anchor Configuration

Figure D.1 shows representative load slip curves for three different anchors. The curves for ½-inch and ¾-inch welded anchors were calculated using the following equations fit to experimental data by Ollgaard et al. (1971).

$$Q = Q_u(1 - e^{-18\Delta})^{0.4} \quad \text{(D.1)}$$

$$Q_u = 1.106 A_s f_c'^{0.3} E_c^{0.44} \quad \text{(D.2)}$$

Where:

Q = Anchor Shear force (kips)

Δ = Anchor shear slip (inches)
f_c' = Concrete compressive strength (ksi)
E_c = Concrete elastic modulus (ksi)
A_s = Cross-section area of the shear anchor (in^2).

Values of f_c' = 5.9 ksi and E_c = 3,257 ksi were used to be consistent with the AP anchor model. The load slip curve from the AP anchor model falls between the ½-inch and ¾-inch curves. Therefore, an equivalent AP anchor diameter of 0.563-inch was estimated by scaling the anchor cross-sectional areas by the ratio of the anchor shear forces (i.e., 13950/24750) at the estimated slip capacities. This is consistent with equation (D.2) where the maximum shear capacity is a direct function of the anchor cross-sectional area. The shear force ratio was used to scale down the shear force data for ¾-inch anchors to the AP anchor configuration, and the equivalent diameter was used to calculate the range in slip capacities from equations provided in Oehlers and Sved (1995).

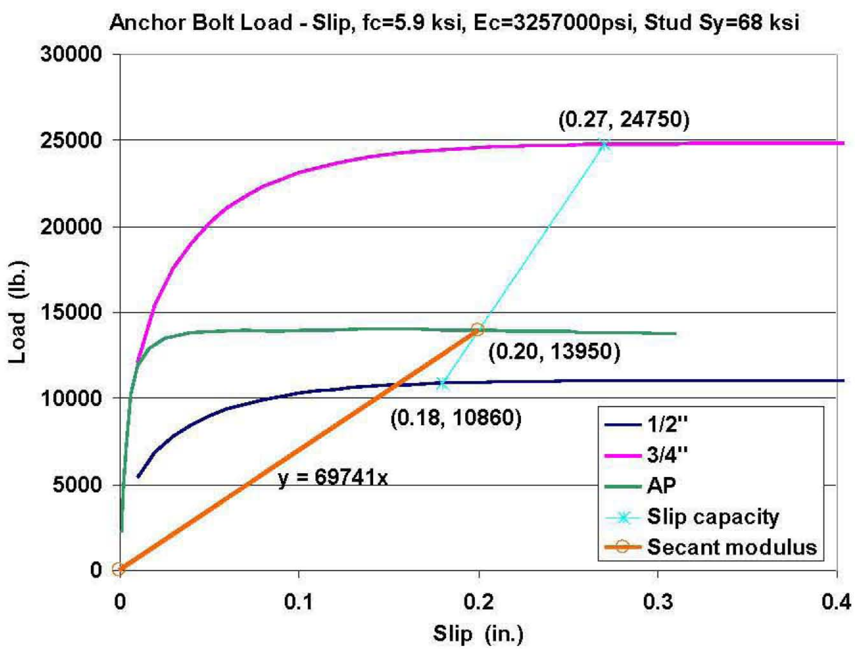

Figure D.1. Load-slip curve for 1/2-inch and 3/4-inch welded studs compared with the finite element prediction for the AP anchor configuration.

D.2.1.2 Estimating the Range of Maximum Shear Force Capacity of the AP Anchors

Figure D.2 shows maximum shear force data from Ollgaard et al. (1971) and Lam and El-Lobody (2005) for ¾-inch anchors tested in concretes with a range of compressive strengths. Note that the data point from Hungford (2004) provided by Richard Klingner is also plotted. A linear fit through the data from Lam and El-Lobody (2005) provides a reasonable mean value curve. Figure D.3 shows this curve scaled by the shear force ratio (13950/24750) to estimate the range in maximum shear capacity of the AP anchors as a function of concrete compressive strength.

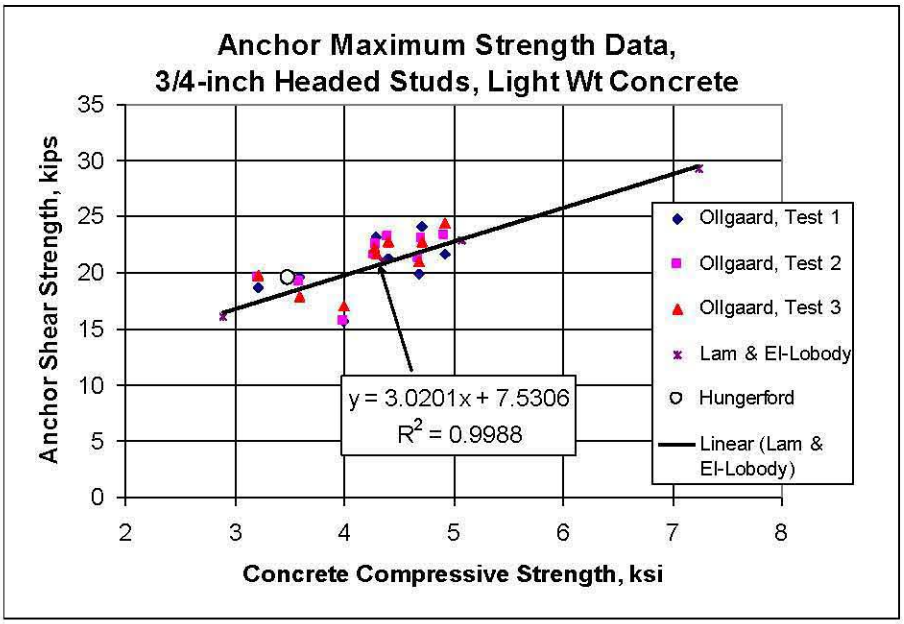

Figure D.2. A compilation of maximum shear force data for 3/4-inch headed, welded studs.

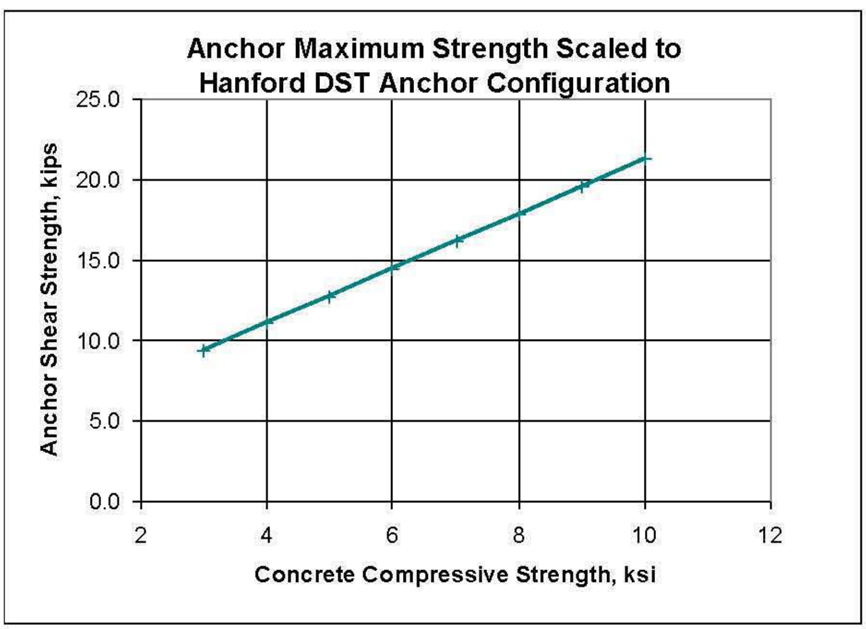

Figure D.3. Maximum shear force scaled down to represent the AP anchor configuration.

D.2.1.3 Estimating the Range of Shear Slip Capacity at the Maximum Shear Force

Oehlers (1995) provides the following equation for estimating the shear slip, S_U, that corresponds to the maximum (or ultimate) shear force

$$S_U/d_s = 0.41 - 0.0030f_c \tag{D.3}$$

where d_s is the anchor bolt shank diameter and f_c is the concrete strength in N/mm^2 (MPa). The parameter, S_U/d_s, has a standard deviation of 0.030. Figure D.4 shows the mean value curves for shear slip at the maximum load for anchor diameters of both ¾-inch and 0.563-inch.

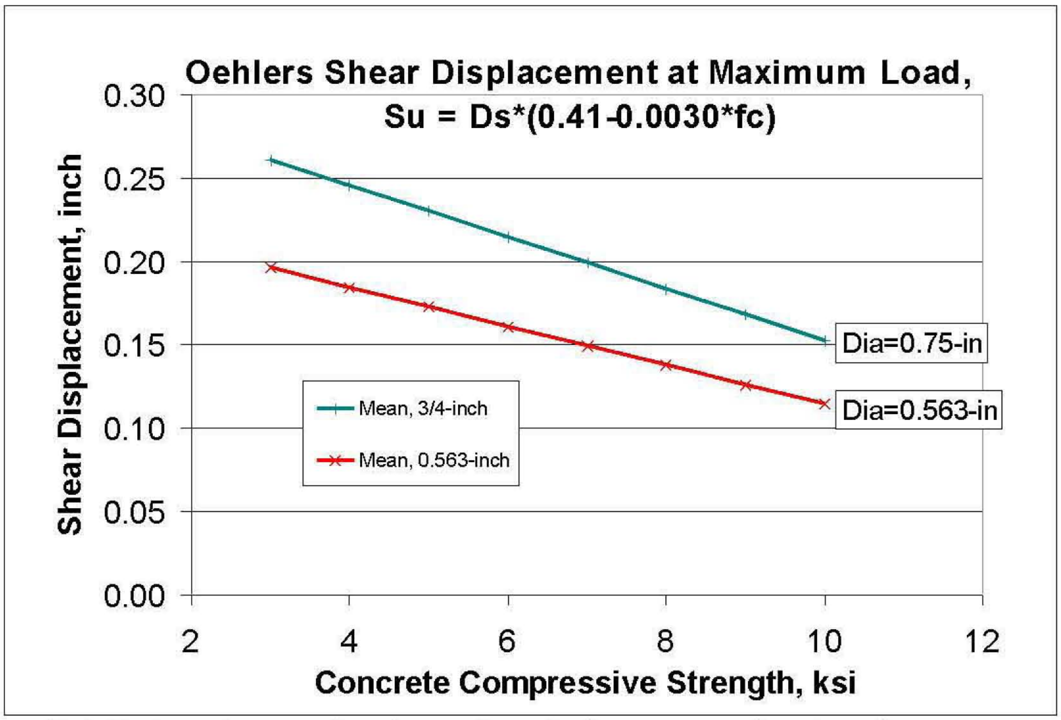

Figure D.4. Estimated range of maximum shear displacement as a function of concrete strength.

D.2.1.4 Calculating bounds on Secant Shear Stiffness Based on Maximum Load and Displacement

The secant modulus at the maximum anchor shear load can then be calculated from the maximum load and shear displacement curves for the range of concrete strengths. Table D.2 lists the maximum shear forces and displacements and the resulting secant moduli. Figure D.5 plots the secant stiffness as a function of concrete strength.

Table D.2. Maximum anchor shear force and displacement and the resulting anchor secant stiffnesses.

		StudDia-in		
		0.563		
Concrete Strength fc, ksi	Concrete Strength fc, N/mm^2	Mean ShearDisp inch	Anchor Strength kips	Secant Modulus kip/inch
3	20.69	0.20	9.4	47.74
4	27.58	0.18	11.1	59.99
5	34.48	0.17	12.8	73.90
6	41.37	0.16	14.5	89.83
7	48.27	0.15	16.2	108.23
8	55.16	0.14	17.9	129.75
9	62.06	0.13	19.6	155.25
10	68.95	0.11	21.3	185.94

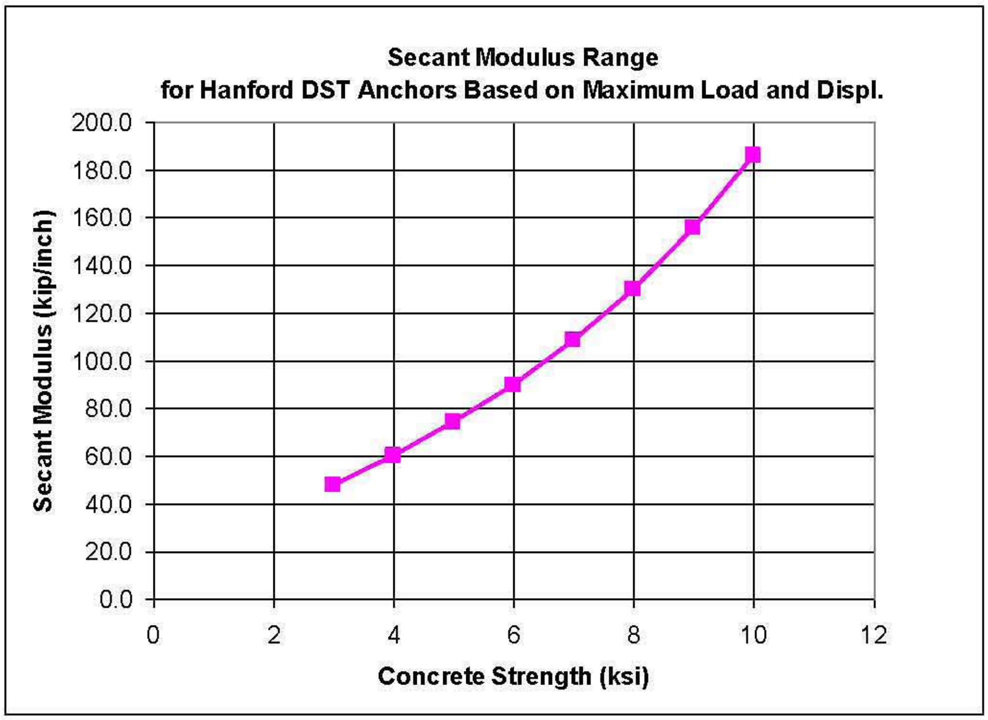

Figure D.5. Mean secant stiffnesses estimated based on estimated maximum shear load and displacement of the AP headed anchors.

D.2.1.5 Calculating bounds on Secant Shear Stiffness Based on Failure Load and Displacement

The anchor failure load is typically lower than the maximum load and it occurs at a greater shear slip displacement as the anchor begins to bend over and pull out. Figure D.6 reproduces a plot from Oehlers and Sved (1995) that shows this behavior and estimates that the failure force is about 95% of the maximum force.

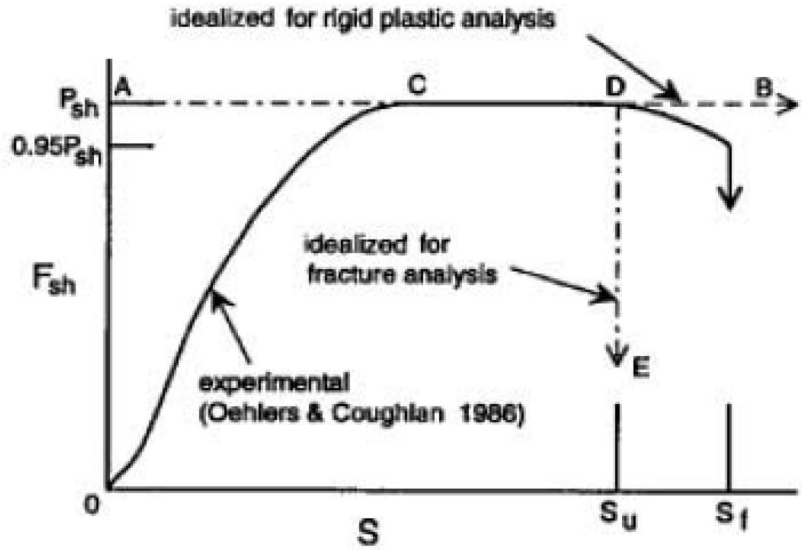

Figure D.6. Characteristic shape of the anchor load slip curve (Oehlers and Sved, 1995).

Therefore, the equations for maximum anchor force used in Figure D.3 were multiplied by 0.95 to estimate the shear failure load. Figure D.7 shows these results graphically. Oehlers and Sved (1995) provide the following equation from which to estimate the shear slip at failure.

$$S_f/d_s = 0.45 - 0.0021 f_c \tag{D.4}$$

where S_f is the slip at fracture, d_s is the anchor bolt shank diameter and f_c is the concrete strength in N/mm^2. The parameter, S_f/d_s, has a standard deviation of 0.048. Figure D.8 shows the shear failure displacement for ¾-inch and 0.563-inch anchors.

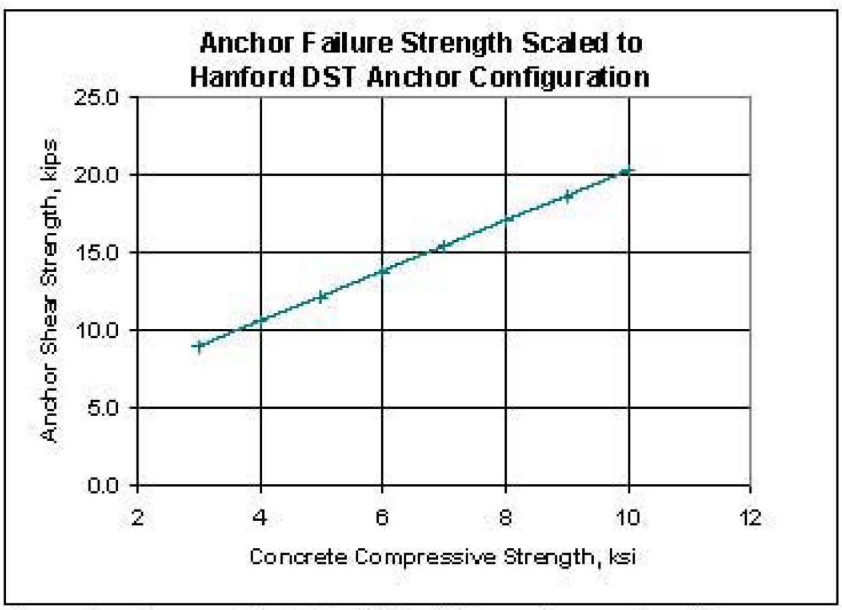

Figure D.7. Failure shear force estimated as 95% of the maximum shear force curves in Figure D.3.

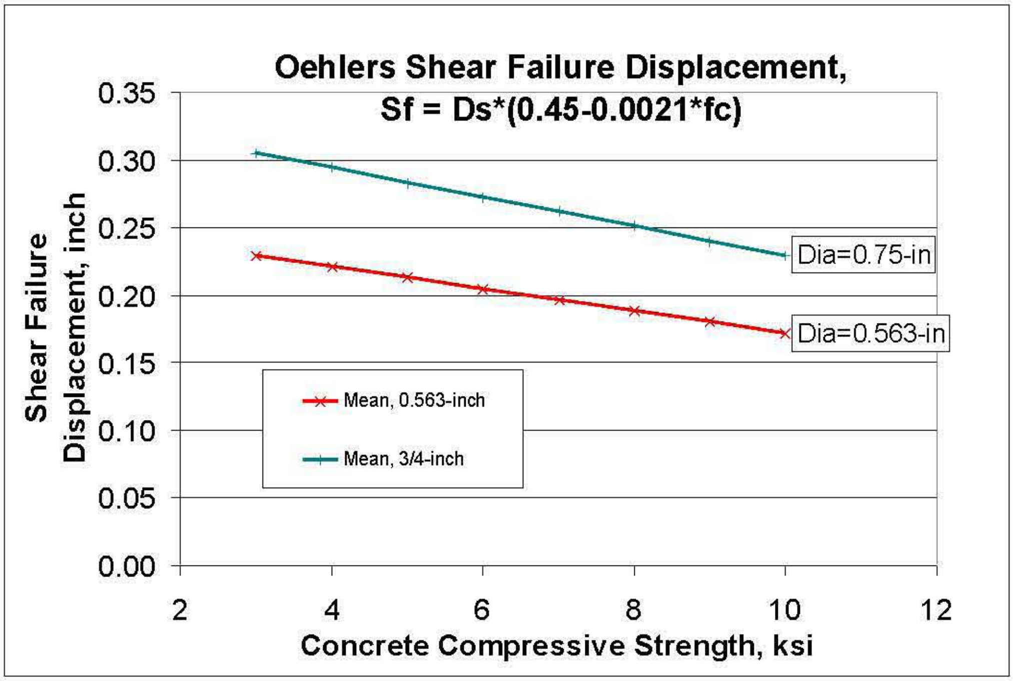

Figure D.8. Estimated range of shear failure displacement as a function of concrete strength.

Table D.3 lists the estimated shear failure forces and displacements and the resulting secant moduli. Figure D.9 plots the secant stiffness as a function of concrete compressive strength.

Table D.3. Anchor shear force and displacement at failure and the resulting anchor secant stiffnesses.

		StudDia-in		
		0.563		
Concrete Strength fc, ksi	Concrete Strength fc, N/mm^2	Mean ShearDisp inch	Anchor Strength kips	Secant Modulus kip/inch
3	20.69	0.23	8.9	38.81
4	27.58	0.22	10.5	47.57
5	34.48	0.21	12.1	57.00
6	41.37	0.20	13.7	67.18
7	48.27	0.20	15.4	78.21
8	55.16	0.19	17.0	90.20
9	62.06	0.18	18.6	103.27
10	68.95	0.17	20.2	117.58

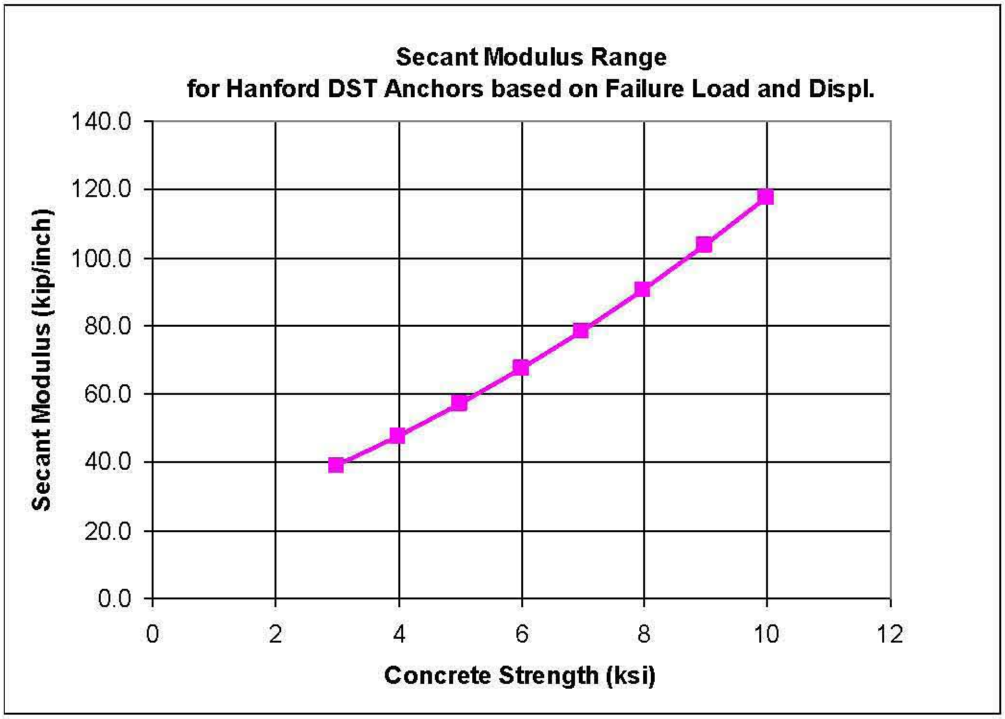

Figure D.9. Secant stiffness based on estimated failure shear load and displacement of the AP headed anchors.

D.2.1.6 Choice of Secant Stiffnesses and Shear Displacement Limits for Bounding Tank Calculations

The Portland Cement Association (PCA) test data on Hanford tank concretes was reviewed to estimate a reasonable range of concrete strengths for which to calculate bounding anchor secant moduli. Henager et al. (1988) plots the test data for concrete strengths of 3 ksi and 4.5 ksi at temperatures of 250°F, 350°F and 450°F.

The plots for 3 ksi and 4.5 ksi at 250°F are reproduced here as Figures D.10 and D.11. The data points show that the tested strengths ranged from about 4.5 ksi to 7.2 ksi. Therefore, a strength range of 4 to 8 ksi was chosen to define upper and lower bound secant moduli for the structural sensitivity studies. The secant moduli based on estimated failure load and displacements (Table D.3 and Figure D.9) were used for initial sensitivity cases. These bounding secant moduli and the recommended anchor shear displacement limits at failure are:

<u>4 ksi concrete</u>, Min. Secant Modulus = 47 kip/inch, Max. Anchor Displacement = 0.22 inch
<u>8 ksi concrete</u>, Max. Secant Modulus = 90 kip/inch, Max. Anchor Displacement = 0.19 inch

A further bound on the secant modulus was investigated by postulating an anchor bolt embedded in fully cracked concrete. The secant modulus was taken to be 1/2 the lower bound or 23.5 kip/inch. The maximum anchor displacement was taken to be twice the lower bound displacement – 10% or 0.40 inch.

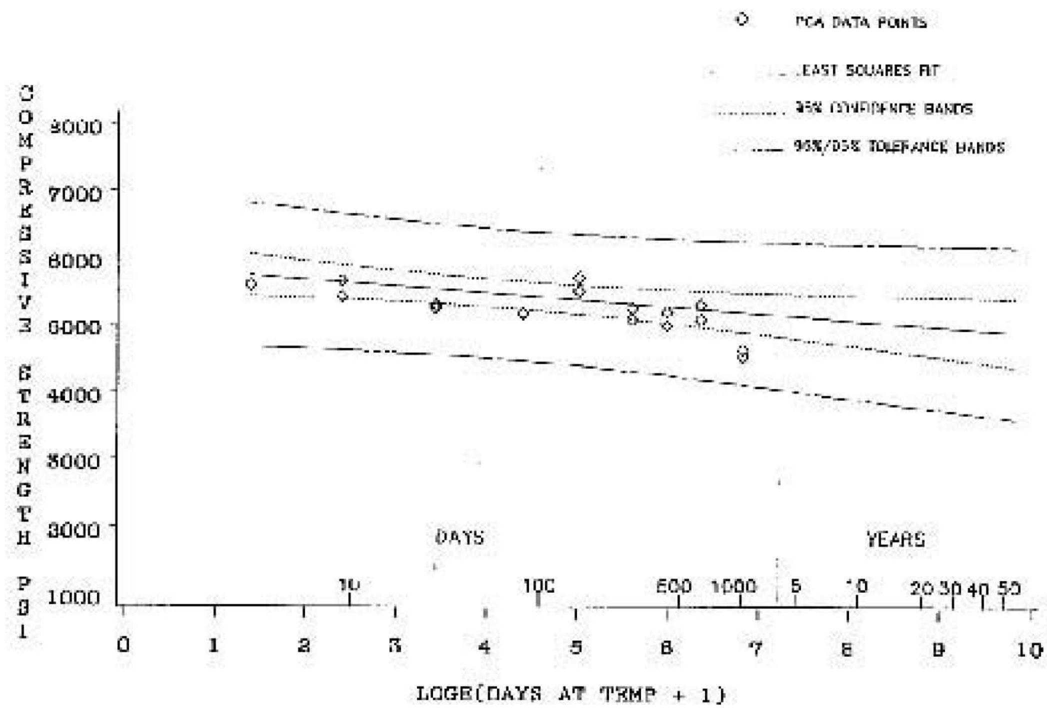

Figure D.10. Compressive Strength Versus Time at 250°F for 3 ksi Hanford Concrete (Figure 10 from Henager et al. 1988).

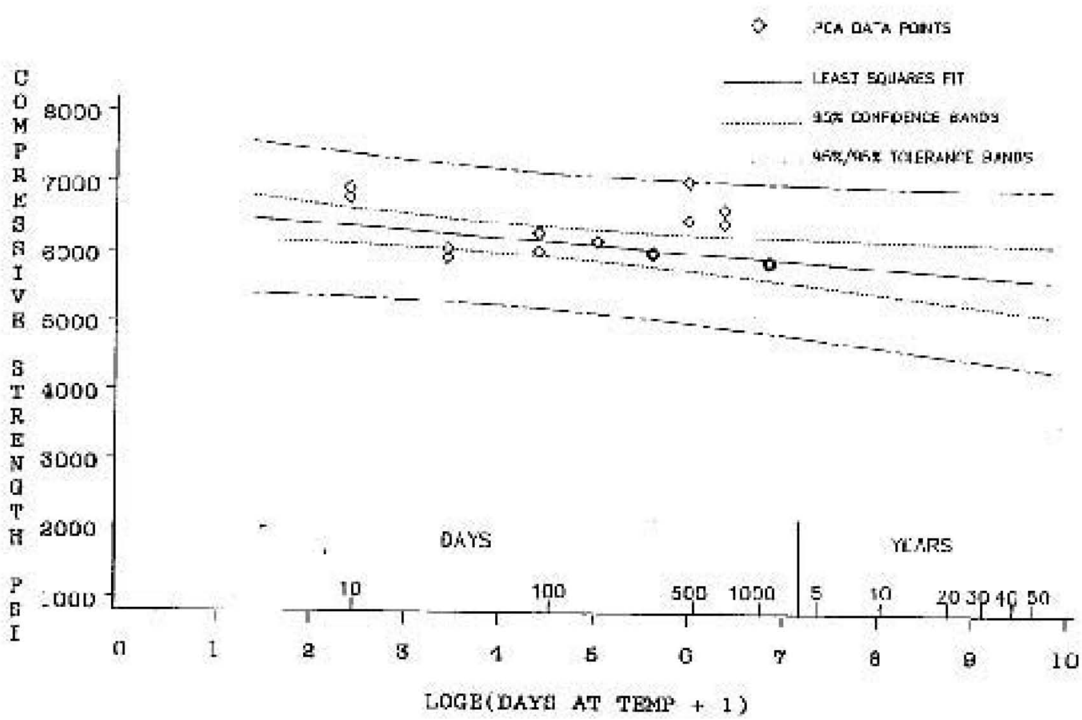

Figure D.11. Compressive Strength Versus Time at 250°F for 4.5 ksi Hanford Concrete (Figure 13 from Henager et al. 1988).

D.2.2 Development of Axial Secant Stiffness

The Nelson Design Data (Nelson, 1961) was reviewed in order to develop a tensile axial secant stiffness for the anchor bolts. Figure D.12 illustrates the load-displacement curves taken from this report for 1/2 inch diameter bolts. Overlaid is a line at 47 kip/in, the lower bound shear secant stiffness. The close correlation between the axial and secant stiffness led to the decision to prescribe identical axial and shear secant stiffnesses for the DST models.

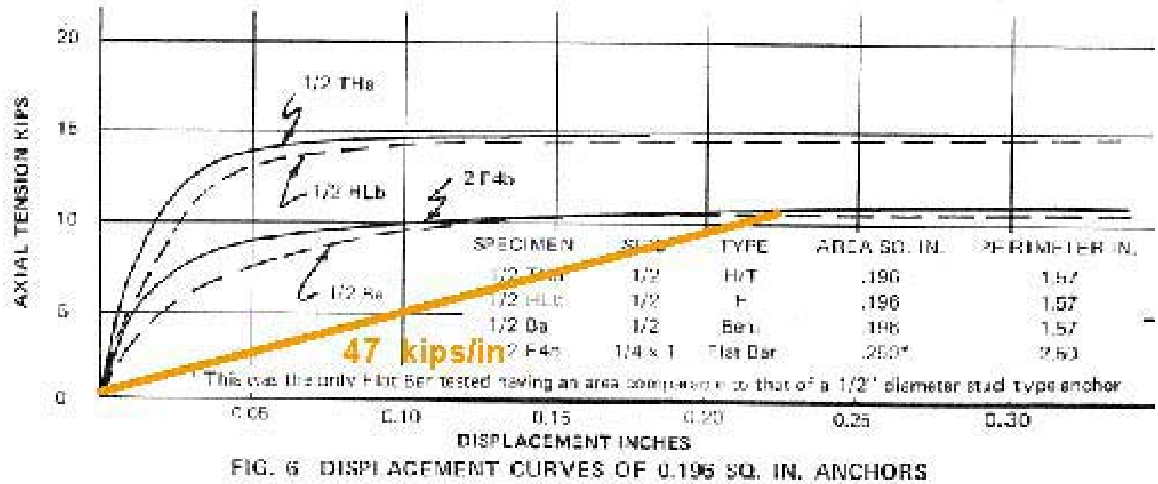

Figure D.12. Load - displacement curve of 1/2 inch anchors (Figure 6 from Nelson 1961).

Maximum tensile displacements from the anchor bolt tests were also reported by Nelson (Nelson, 1961), see Table D.4. Accordingly, the maximum anchor axial tensile displacement was specified as 0.44 inch.

Table D.4. Maximum displacement of 1/2 inch anchors (Table VII from Nelson 1961).

TABLE VII
DISPLACEMENTS OF BENT STUD ANCHORS

Stud Dia., inches	Displacements, inches at 0.50 $P_{y(B)}$	at 0.85 $P_{y(B)}$	at Failure
1/2	0.014	0.038	>0.44
5/8	0.015	0.051	>0.42
3/4	0.018	0.058	>1.0
1	0.023	0.094	>1.5

D.3 Evaluation

Changes have been made to the evaluation of the anchor bolts in addition to changes to the modeling techniques. These are described in the following sections.

D.3.1 Shift from ASME to ACI 349-01 Evaluation Criteria for the Anchor Bolts

It was suggested by the reviewers that the implementation of the 0.5 strength reduction factor may be unduly conservative (Appendix B, Deibler et al. 2008). It was noted that AISC and ACI permit the use of a strength reduction factor $\phi = 0.75$. Accordingly, the current evaluation of the anchor bolts was revised and is based on the procedure given in ACI 349-01. The original evaluation of the anchor bolts was performed using ASME B&PVC evaluation criteria as recommended in Day et al. (1995). The ASME B&PVC criteria are intended for the design of concrete containments in nuclear facilities. Since 1995, the DSTs have been downgraded from PC-3 to PC-2 structures, and the application of the concrete containment code to the anchor bolt evaluation is viewed as unnecessarily restrictive. The change of criteria from ASME (specifying a 0.50 load reduction factor) to ACI 349 (0.75 load reduction factor) has the effect of increasing the capacity of the anchors by 50%.

D.3.2 Displacement Evaluation

Implicit in the use of the secant stiffness for the anchor bolt is a switch from a force evaluation criterion to a displacement criterion. Details of the development of the maximum anchor displacement are found is section D.2.1 above.

Appendix D.7 of ACI 349-01 describes the following equations for evaluation of the interaction of tensile and shear force:

If $V_u \leq 0.2\phi V_n$ then $\phi N_n \geq N_u$

If $N_u \leq 0.2\phi N_n$ then $\phi V_n \geq V_u$

If $V_u > 0.2\phi V_n$ and $N_u > 0.2\phi N_n$ then $\dfrac{N_u}{\phi N_n} + \dfrac{V_u}{\phi V_n} \leq 1.2$

Similar equations were used for the evaluation of the anchor bolt displacements.

D.3.3 Sources of Analytical Conservatism

- So far, a simplified routine that smears spatial and temporal results has been used to calculate peak seismic demands. Use of a more refined methodology is estimated to reduce the seismic demand by approximately 5-10%.
- The TOLA and seismic demands reported do not credit any friction between the concrete dome and the steel tank. Initial indications are that the benefit of friction may reduce the demands by approximately 5%.
- The most recent site response analyses performed at the Hanford Site Waste Treatment Plant (WTP) Site show that the currently published design spectra for the WTP Site are significantly

lower than the interim spectra published in 2005 (PNNL 2007). This indicates that the governing spectra being used for the DST analysis are likely to be conservative.

D.3.4 Additional Considerations

- The project team has sought technical support from ACI 349 Code Committee member Richard E. Klingner. Professor Klingner is an expert in anchorage to concrete and has been contracted to assist in questions of ACI code interpretation and treatment of thermal demands on the anchor bolts. In the interim, the anchor bolt evaluation will proceed using conservative assumptions for the treatment of thermal demands.

- The focus so far has been on calculating the demand-to-capacity ratios for the anchor bolts. The larger question of the safety function that is performed by the anchor bolts and the degree of structural stability provided by the anchor bolts has not been addressed. If it can be shown that the system remains stable with some or all of the anchor bolts removed from the load path, this will add defense-in-depth to the arguments supporting the evaluation of the anchor bolts.

D.4 Conclusions

The secant modulus anchor bolt modeling is a viable method of accommodating the nonlinear load-displacement response. Use of the ACI/AISC strength reduction factor provides a 50% increase in capacity.

D.5 References

ACI. 1990. *American Concrete Institute Code Requirements for Nuclear Safety Related Concrete Structures*. ACI 349-90, American Concrete Institute, Detroit, Michigan.

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Day JP, AD Dyrness, LJ Julyk, CJ Moore, WS Peterson, MA Scott, HP Shrivastava, JS Shulman, and TN Watts. 1995. *Structural Acceptance Criteria for the Evaluation of Existing Double-Shell Waste Storage Tanks Located at the Hanford Site, Richland, Washington.* WHC-SD-WM-DGS-003, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Deibler JE, MW Rinker, KI Johnson, FG Abatt, SP Pilli, and NK Karri. 2008. *Hanford Double-Shell Tank Thermal and Seismic Project - Increased Liquid Level Analysis for 241-AP Tank Farms.* RPP-RPT-32237, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington.

Lam D and E El-Lobody. 2005. "Behavior of Headed Stud Shear Connectors in Composite Beam." *Journal of Structural Engineering* 131:1.

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Nelson. 1961. *Design Data, Nelson Concrete Anchor Studs,* Manual No. 21, TRW Nelson Stud Welding Division, Elyria, Ohio.

Oehlers DJ and G Sved. 1995. "Composite Beams with Limited-Slip-Capacity Shear Connectors." *Journal of Structural Engineering* 121:6.

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E Level 1 Heading

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Appendix E

ANSYS Model Files

Appendix E

ANSYS Model Files

E.1 Introduction

The majority of the ANSYS input files are found in their respective reports, TOLA (Rinker et al. 2004) and the ANSYS Seismic Report (Carpenter et al. 2006). This appendix contains the ANSYS model input files for the Upper Bound Soil case which has not been previously reported. There are twenty-six files needed to actually build the model and the run stream. The master input file is the "set_slicea.mac" macro file. The set_slicea.mac file calls all of the other necessary files for the actual ANSYS run. At the end of a given thermal cycle, a database file, created in ANSYS, is copied into a new subdirectory along with the twenty-six temperature distribution macro files that apply the temperatures via body forces to each node point in the model (note there is no relationship between the twenty-six model files and the twenty-six temperature files) and a short input macro file to re-start the ANSYS run. The actual nodal temperature values are not included in this appendix, as it would take over four thousand pages to do so. The actual nodal temperatures are included separately on electronic media. The ACI load factors are applied at the end of the thermal cycles (for the appropriate load combinations).

The post-processing files required to extract the results from the TOLA model in preparation for combination with the seismic results are shown at the end of this appendix.

E.2 Upper Bound Soil Model Input Macro Files

E.2.1 Model files

Input file: set_slicea.mac

```
!***
!***    Upper bound soil   11/21/05
!***2nd liner extension 0.25 thick                    7/21/04
!***2nd liner extension contact <> concrete   7/21/04
!*** Augmented stiffness 5% Econc (350)   7/19/04
!***5% pivot, bcso,mmd            6/25/04
!***Use nsub                6/24/04
!***cnvtol,f(m),,.005,0   6/16/04
!*** Augmented stiffness 2% Econc (350)   6/14/04
!*** Augmented stiffness 30000   6/11/04
!***6/10/04 changes
!***    Do not merge insulating concrete <> 2nd liner @
OD of concrete
!***    Add 1st radius element to contact of 1st liner <>
ins conc
!***    Add contact 2nd liner <> slab concrete
!***Correct node select for type,61 real,70   6/9/04
!***Reorient Beam188 on z=/= 0 face
!***Fix Liner-Dome common nodes   5/6/04
!***Delete "J-bolts" in wall   5/6/04
!***Move J-bolt real definition to pnnla6.mac  3/30/04
!***Changed Liner Coupling per J. Deibler 3/29/04
!!***     Augmented stiffness 15000   3/24/04
!***Default convergence criteria  3/22/04
!***Best estimate soil properties  3/19/04
!***Soil-Concrete - 5 regions  2/23/04
!***Correct Drucker-Prager - soil
!***Correct mat,1 temperature dependent modulus
!***Replace shell64 with shell181
!***Primary tank pressure -12" H2O (was -6)
!***125 pcf overburden, 110 pcf undisturbed soil
!***10/30/03
!***Define additional soils for load factor restart
!***No cracking insulating concrete
!***fix mpch (esel,r,mat,,2)
!***1 yr + 15 day creep  5/14/03
!***    Load step 5 creep for 330 days
!***New load step 6 => mpch +5 days
!***   "sets" degraded concrete properties
!***
!***    Turn off concrete crushing 5/5/03
!***
!*** Run 2, Load Step 1, 2 & thermal
!***   (8.3' soil, 125 lb/ft3)
!***   (0.06" primary tank corrosion wall, floor)
!*** 4/16/03
!***
!***
!*** JED mods 3/29/03
!***

i_rebuild=1
*if,i_rebuild,eq,1,then
 pnnla
```

```
 pnnla2
 pnnla3
 pnnla4
 pnnla5
 pnnla6
 pnnla7
 pnnla8
 pnnla9
*else
 resume,pnnla9,db
*endif

/prep7

allsel
cpdele,all,all

!get misc area components for applying loads, etc.
/input,set_areas_slice,mac

!add steel plate below wall (on slab)
r,45,1/4
csys,22
vsel,s,mat,,2
aslv
asel,r,loc,z,-8.125
asel,r,loc,x,480,498
aatt,1,45,22
mat,1
real,45
amesh,all
```

```
!define contact elements (all have default friction of 0.3)
et,60,170
et,61,173
mp,mu,61,.3              !Soil-concrete dome
,mu,62,.4
,mu,63,.4
,mu,64,.4
,mu,65,.3
,mu,66,.2
,mu,67,.05               !soil-concrete wall
,mu,68,.3                !soil-concrete footing/top
,mu,69,.05               !soil-concrete footing/side
,mu,70,.6                !soil-concrete foundation
,mu,71,.4                !2nd liner-insulating concrete
6/10/04

!soil_concrete contact - dome
r,61,,,1,.1
real,61
type,61
mat,61
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,z,452,600
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,452,600
```

E.3

```
esln
esurf

!soil_concrete contact - wall
r,67,,,1,.1
real,67
type,61
mat,67
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,z,-3,453
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,-3,453
esln
esurf

!soil_concrete contact - Footing - top
r,68,,,1,.1
real,68
type,61
mat,68
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,z,-7,-6
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,-7,-6
,r,loc,x,496,530
esln
esurf

!soil_concrete contact - Footing - side
r,69,,,1,.1
real,69
type,61
mat,69
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,x,531
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,x,531
esln
esurf

!soil_concrete contact - Foundation
r,70,,,1,.1
real,70
type,61
mat,70
cmsel,s,aconc_soil
nsla,,1
```

```
nsel,r,loc,z,-31,-30
,r,loc,x,440,531
cm,foundconc,node
nsla,,1
nsel,r,loc,x,,440
,r,loc,z,-33,-8              !** was -32  6/9/04
cmse,a,foundconc
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,-31,-30
,r,loc,x,440,531
cm,foundsoil,node
nsla,,1
nsel,r,loc,x,,440
,r,loc,z,-33,-8
cmse,a,foundsoil
esln
esurf


!secondary liner contact
r,62,,,1,.1
real,62
type,60
mat,62
cmsel,s,aconc_shell
csys,0
asel,u,loc,y,459,99999
nsla,,1
esln
esel,r,mat,,2
esurf
type,61
cmsel,s,area_secon
csys,0
asel,u,loc,y,-99999,3.87
nsla,,1
esln
esurf

!primary liner contact with dome
r,63,,,1,.1
real,63
type,60
mat,63
cmsel,s,aconc_shell
asel,r,loc,y,459,99999
nsla,,1
esln
esel,r,mat,,2
esurf
type,61
cmsel,s,area_prim
asel,r,loc,y,459,99999
nsla,,1
esln
esurf

!primary liner contact with insulating concrete
```

```
r,64,,,1,.1
real,64
type,60
mat,64
cmsel,s,area_insul_top
nsla,,1
esln
esel,r,mat,,4
esurf
type,61
cmsel,s,area_prim
csys,0
asel,r,loc,y,0
nsla,,1
esln
nsle      !*6/10/04
esurf

!secondary liner contact with foundation concrete  6/10/04
r,71,,,1,.1
real,71
type,60
mat,71
cmse,,slab_top
asel,r,loc,x,-480,-440
nsla,,1
esln
esur
type,61
cmse,,area_secon
asel,r,loc,x,-470,-440
,r,loc,y,-9,-8
nsla,,1
esln
nsle
esur

!merge insulating concrete bottom nodes and secondary
liner nodes
cmsel,s,area_insul_bot
cmsel,a,area_secon
csys,0
asel,u,loc,y,20,9999
nsla,,1
cpintf,uz,.1

!slab top/insulating concrete
r,65,,,1,.1
real,65
type,60
mat,65
cmsel,s,slab_top
nsla,,1
esln
esurf
type,61
cmsel,s,area_insul_bot
nsla,,1
esln
esurf

!wall/slab contact
```

```
r,66,,,1,.1
real,66
type,60
mat,66
asel,,,,986,992
cm,slab_top_wall,area
nsla,,1
esln
esel,r,mat,,2
esurf
type,61
asel,,,,214
,a,,,706
,a,,,913,918,5
,a,,,934
cm,wall_bot,area
nsla,,1
esln
esel,r,mat,,2
esurf

allsel
!esel,s,type,,60
!nsle
!nummrg,node
!nummrg,elem
!esel,s,type,,61
!nsle
!nummrg,elem

max_mat=100
max_real=1000

!define the local coordinate systems and rebar orientations
/input,set_esys_3d,mac

!apply loads
/input,apply_loads_slice,mac
allsel

!apply axisymmetric boundary conditions
csys,22
nsel,s,loc,y,180
nsel,a,loc,y,180+swp_th-.001,183
csys,0
nsel,a,loc,x,0
d,all,uy,0
d,all,rotx,0
d,all,rotz,0
allsel

nsel,s,loc,x,0
d,all,roty,0

!merge liner/concrete nodes at dome centerline
ksel,s,,,2
ksel,a,,,329
nslk
nummrg,node
allsel

!copy jbolts, etc for slice model
```

```
csys,22
esel,s,type,,20,21
cm,e_bolt0,elem
egen,2,500000,all,,,0,0,0,0,0,,swp_th
esel,s,mat,,1
esel,u,real,,45
nsle
nsel,u,,,22789,22790      !*** 5/6/04
,u,,,20260,20261!*** 6/10/04
nummrg,node

!divide jbolt/bottom anchors properties by 2 for slice
model
r,30,.19635/2,.3068e-2/2,.3068e-2/2,.5,.5

esel,s,type,,20,21
cmsel,u,e_bolt0
nsle
nsel,r,,,500000,999999
cm,ntemp,node

vsel,s,mat,,2
vsel,a,mat,,6
csys,0
vsel,u,loc,y,-9999,-8.12
cm,vtemp,volu
*get,nv,volu,,count
*do,i,1,nv
 *get,iv,volu,,num,min
 eslv
 nsle
 cmsel,a,ntemp
 nummrg,node
 cm,ntemp,node
 cmsel,s,vtemp
 vsel,u,,,iv
 cm,vtemp,volu
*enddo

!***
!***  Delete primary-secondary tank coupling at tangent
!***   JED 3/31/03
!***

r,41,3/16                    !insulating concrete confining
ring thickness

/prep7

esel,s,mat,,5
nsle,,1
csys,0
*get,top_elev,node,,mxloc,y
cm,soil_elem,elem

*do,i,1,16
 set_slayer,soil_z0(i),soil_z1(i),soil_emod(i),soil_pr(i)
*enddo

max_mat=100
!set backfill/overburden material
*do,i,1,8
```

```
 set_backfill,bf_z0(i),bf_z1(i),bf_emod(i),bf_pr
*enddo

!Don't do this!! 5/6/04
!make sure anchors/jbolts/studs etc are merged with
concrete
!esel,,type,,12,13
!,a,type,,20,21
!,a,type,,24,25
!nsle
!nsel,u,,,22789,22790      !*** 3/26/04
!numm,node


!***
!*** Augmented Stiffness  2/27/04
!***
et,32,45
*get,ec350,ex,2,temp,350
mp,ex,12,ec350*0.05                 !7/19/04
,prxy,12,.15
esel,,type,,12,15
egen,2,0,all,,,10
esel,,mat,,12
emod,all,type,32

/fil,set_slice_0
save

!***
!***Redefine J-bolts  4/1/04
!***

alls
csys
nod0k=node(-550,575,0)
nod1k=node(-550,575,27)
et,30,188                    !New J-bolts
type,30
mat,1
real,20
secn,2
sect,2,beam,csolid
secd,.25/(2**.5),1,1         !Use 1/2 area for symmetry
esel,,type,,20
nsle
nsel,r,loc,z
esln,,1
*get,jb0,elem,,count
*do,i,1,jb0
*get,jb1,elem,,num,min
*get,jn1,elem,jb1,node,1
*get,jn2,elem,jb1,node,2
e,jn1,jn2,nod0k
esel,u,,,jb1
*enddo

esel,,type,,20
nsle
nsel,u,loc,z
esln,,1
*get,jb2,elem,,count
```

E.10

```
*do,i,1,jb2
*get,jb3,elem,,num,min
*get,jn3,elem,jb3,node,1
*get,jn4,elem,jb3,node,2
e,jn3,jn4,nod1k
esel,u,,,jb3
*enddo

allsel


!***  2nd liner extension issues   7/21/04
asel,,,,928,,,1
egen,2,100000,all,,,,,4,,,0,0,0
modm,nocheck
alls
emod,15784,-1,114183,104465
,15955,-3,104465,114183
,28878,-3,104465,114183
acle,928
real,62
type,60
mat,62
asel,,,,928,,,1
esln
esel,r,type,,12
esurf
type,61
esel,,type,,23
,r,real,,45
nsle
esurf
dsym,symm,y,5
alls

!***
!***   Temperatures
!***     Uniform 50F  (4/17/03)
!***
tref,50
tunif,50

finish
/filnam,set_slice_0
/sol
!solcontrol,off
neqit,50
time,1
nlgeom,on
nrop,unsym
cnvt,f,,.005,0                  !6/16/04
,m,,.005,0                      !6/16/04
crpl,.05
nsub,10,100,5
!delt,.1,.01,.2
!outres,all,all
!nrre,on,250
eqsl,sparse,.05,-1
bcso,mmd
allsel
save
solve
```

```
time,2
!***
!***  Add waste and pressure loads
!***
pres_surf=0                          !ground surface
uniform pressure psf
point_cent=0                         !point load at
center lb
pres_annulus=-20                     !annulus
pressure inches h2o
pres_int=-12                         !annulus internal
pressure inches h2o
hwaste=35.17*12                            !total
waste height
height_waste1=hwaste/3               !height of waste
1 inches
gamma_waste1=1.7                     !specific gravity
of waste 1
height_waste2=hwaste/3               !height of waste
2 inches
gamma_waste2=1.7                     !specific gravity
of waste 2
height_waste3=hwaste/3               !height of waste
3 inches
gamma_waste3=1.7                     !specific gravity
of waste 3

/inp,apply_loads_slice,mac

delt,.1,.01,.25
solv

time,3
!***
!***  Add surface loads
!***
pres_surf=40                         !ground surface
uniform pressure psf
point_cent=200000                    !point load at
center lb
pres_annulus=-20                     !annulus
pressure inches h2o
pres_int=-12                         !annulus internal
pressure inches h2o
hwaste=35.17*12                            !total
waste height
height_waste1=hwaste/3               !height of waste
1 inches
gamma_waste1=1.7                     !specific gravity
of waste 1
height_waste2=hwaste/3               !height of waste
2 inches
gamma_waste2=1.7                     !specific gravity
of waste 2
height_waste3=hwaste/3               !height of waste
3 inches
gamma_waste3=1.7                     !specific gravity
of waste 3

/inp,apply_loads_slice,mac
```

```
save
solv
```

Input file: apply_loads_slice.mac

```
!***
!***Eliminate in-plane pressure 2nd liner
!*** Add pressure 1st liner @ connection
!*** 12/4/03
!***

allsel
sfdele,all,all
sfedele,all,all,all
sfgrad,pres
fdele,all,all
esel,s,type,,59
edele,all

!40 psf pressure on ground surface
!***
!*** No pressure - Phase II, Load Case S5
csys,0
*get,ymx,kp,,mxloc,y
asel,s,loc,y,ymx
lsla
nsla,,1
esel,all
sf,all,pres,pres_surf/144

!200K point load at center
!***
!*** No concentrated load - Phase II, Load Case S5
csys,22
nsel,r,loc,x,0,clr
*get,nnode,node,,count
f,all,fz,-point_cent/nnode*swp_th/360

!liner pressure loads
p_annulus=pres_annulus/12*62.4/144
p_internal=pres_int/12*62.4/144

!waste depth and unit weight
hw1=height_waste1
gammaw1=gamma_waste1
hw2=height_waste2
gammaw2=gamma_waste2
hw3=height_waste3
gammaw3=gamma_waste3

*if,abs(gammaw1),lt,1e-3,then
 gammaw1=1e-6
*else
 gammaw1=gammaw1*62.4/1728
*endif
*if,abs(gammaw2),lt,1e-3,then
 gammaw2=1e-6
*else
 gammaw2=gammaw2*62.4/1728
*endif
*if,abs(gammaw3),lt,1e-3,then
 gammaw3=1e-6
*else
```

E.12

E.13

```
 gammaw3=gammaw3*62.4/1728
*endif

zz4=0
zz3=hw1
zz2=zz3+hw2
zz1=zz2+hw3
zz0=460
pp0=p_internal
pp1=p_internal-p_annulus
pp2=pp1+hw3*gammaw3
pp3=pp2+hw2*gammaw2
pp4=pp3+hw1*gammaw1

allsel

!primary liner
esel,s,real,,50,54
nsle
cm,nliner,node

!top reaches of dome
allsel
csys,0
cmsel,s,nliner
nsel,r,loc,y,zz0-.03,9999
sfgrad,pres
sf,all,pres,pp0

!space between top of fluid and prim/secon liner
intersection
cmsel,s,nliner
nsel,r,loc,y,zz1,zz0
sf,all,pres,pp1

!waste region 3
cmsel,s,nliner
nsel,r,loc,y,zz2,zz1
esln
esel,r,type,,1
nsle,,1
sfgrad,pres,0,y,zz1,(pp1-pp2)/hw3
sf,all,pres,pp1

!waste region 2
cmsel,s,nliner
nsel,r,loc,y,zz3,zz2
esln
esel,r,type,,1
nsle,,1
sfgrad,pres,0,y,zz2,(pp2-pp3)/hw2
sf,all,pres,pp2

!waste region 1
cmsel,s,nliner
nsel,r,loc,y,zz4,zz3
esln
esel,r,type,,1
nsle,,1
sfgrad,pres,0,y,zz3,(pp3-pp4)/hw1
sf,all,pres,pp3
```

```
!annulus
esel,s,type,,1
nsle,,1
cmsel,u,nliner
nsel,u,loc,y,-9999,-8.124
esln
esel,r,type,,1
nsle,,1
cm,nsecon,node
esln
esel,r,real,,55,56
sfgrad,pres
sf,all,pres,p_annulus

alls
```

Input file: mesh_size.mac

```
eesize=3.2                  !default element size for
rebar [in]
soil_size=14                !default element size for
soil elements [in]
swp_th=24/(2*pi*480)*360    !single element sweep
angle [deg]
num_div=6                   !number of divisions per
quadrant
```

Input file: PNNLA.mac

```
set_parms
/prep7
!  3/28/03
! DST - AY
```

```
*afun,deg

k,1,0,h6
k,2,0,h5
k,3,0,0
k,4,-ir2,0
k,5,ir2,h3+36+6+13/16
k,6,-r1*sin(th1),h6-r1+r1*cos(th1)    !Intersection of
exterior dome radii
larc,6,1,3,r1                  !Exterior dome radius - center

rectng,-ir2,0,h2,h1
rectng,-or,-ir,h2,h3                !Wall to tangent point
rectng,-or,-ir,h3,h4

larc,18,6,3,r2                 !Exterior dome radius - outer
local,11,1,0,h3,0,,,,3/8
l,13,2                                  !Interior dome
ellipse

csys,0
l,1,2
k,19,-ir2,0
k,20,-ir2,h4+5
l,19,20
lcsl,15,17
lfil,18,20,r3                        !Radius primary tank to
dome
csys,11
l,21,22
```

```
nummrg,kp
csys,0

lfil,20,4,12                    !Corner radius primary
tank floor
l,7,12
lfil,23,7,12                    !Corner radius secondary
tank floor

wpcs,-1
wpro,,,-90
wpof,,,icr
asbw,1                          !Insulating concrete

al,8,19,17,18,16,1,14,13 !Haunch & dome concrete

adel,3,4
alls
numc,all

!Tank Foundation
*get,ik,kp,,num,max
k,ik+1,0,h2-24
k,ik+2,-36,h2-24
k,ik+3,-76,h2-10.5
k,ik+4,-29*12-1,h2-10.5
k,ik+5,-36*12-9,ky(ik+4)-11.5
k,ik+6,-44*12-3,ky(ik+5)
k,ik+7,kx(ik+6),ky(ik+6)+12+11.5
k,ik+8,-or-1,ky(ik+7)
k,ik+9,kx(ik+8),ky(ik+8)-1.5
```

```
k,ik+10,-or,ky(ik+9)
k,ik+11,-ir,ky(ik+9)
k,ik+12,-ir+1,ky(ik+9)
a,ik+1,ik+2,ik+3,ik+4,ik+5,ik+6,ik+7,ik+8,ik+9,ik+10,ik+
11,ik+12,8

!Dome & wall rebar
!Outer rebar
k,37,kx(11)+covext,ky(11)          !Outer edge wall outer
rebar - bottom
k,38,kx(37)+1,ky(37)               !Inner edge wall outer
rebar - bottom
k,39,kx(18)+covext,ky(18)-.707     !Outer edge wall
outer rebar - top
k,40,kx(39)+1,ky(39)-.707          !Inner edge wall outer
rebar - top
k,41,kx(6),ky(6)-covext            !Outer dome rebar radius
intersection
k,42,kx(41),ky(41)-1               !Outer dome rebar radius
intersection
k,43,kx(1),ky(1)-covext            !Outer dome rebar -
centerline outer
k,44,kx(1),ky(43)-1                !Outer dome rebar -
centerline inner
larc,39,41,3,r2-covext             !Outer edge of outer rebar,
outer radius
larc,41,43,3,r1-covext             !Outer edge of outer rebar,
center radius
larc,40,42,3,r2-covext-1           !Inner edge of outer rebar,
outer radius
```

E.16

```
larc,42,44,3,r1-covext-1          !Inner edge of outer rebar,
center radius
a,37,38,40,42,44,43,41,39          !Dome outer rebar

!Dome & wall rebar
!Inner rebar
k,45,kx(12)-covint1,ky(12)
,46,kx(45)-1,ky(45)
,47,kx(13)-covint1,ky(13)
,48,kx(47)-1,ky(47)
,55,0,ky(2)+covint2
,56,0,ky(55)+1
loca,12,1,,h3,,,,,(30*12+1.5)/(80*12+1.5)
k,49,ir+1.72,164
,53,ir+2.21,144
l,53,55
loca,13,1,,h3,,,,,(30*12+2.5)/(80*12+2.5)
k,50,ir+2.86,163.9
,54,ir+3.68,143.85
l,54,56
loca,14,1,,h3,,,,,(30*12+4)/(80*12+4)
k,51,ir+5.2,154.8                  !Want 4" cover & 7-1/2"
from tangent
loca,15,1,,h3,,,,,(30*12+5.5)/(80*12+5.5)
k,52,ir+6.4,154.65
csys,0
l,45,47
,46,48
csys,11
a,45,47,49,51,53,55,56,54,52,50,48,46
csys,0

!Foundation rebar
covtop=3.5
covbot=3
ssli=(ky(27)-ky(26))/(kx(27)-kx(26))
sslo=(ky(28)-ky(29))/(kx(28)-kx(29))
k,60,kx(30)+3,ky(30)+covbot
k,61,kx(60),ky(60)+1
k,62,kx(31)+3,ky(8)-covtop
k,63,kx(62),ky(62)-1
k,64,0,ky(8)-covtop
k,65,0,ky(64)-1
k,74,0,ky(25)+covbot+1
k,75,0,ky(25)+covbot
k,66,kx(26)-ssli*covbot,ky(26)+covbot
k,67,kx(66)-ssli,ky(66)+1
k,68,kx(27)-ssli*covbot,ky(27)+covbot
k,69,kx(68)-ssli,ky(68)+1
k,70,kx(28)-sslo*covbot,ky(28)+covbot
k,71,kx(70)-sslo,ky(70)+1
k,72,kx(29)-sslo*covbot,ky(29)+covbot
k,73,kx(72)-sslo,ky(72)+1
a,60,61,73,71,69,67,74,75,66,68,70,72
a,62,64,65,63

!Haunch mid section rebar
k,80,kx(14)+11+.5,ky(14)+36
k,81,kx(80),ky(40)
k,82,kx(80),.5*(ky(80)+ky(81))
k,83,kx(14)+72,ky(14)+98
k,84,kx(14)+103,ky(14)+113
```

E.17

```
k,85,kx(84),ky(84)+1
k,86,kx(83),ky(83)+1
k,87,kx(82),ky(82)+1
k,88,kx(81)-1,ky(81)
k,89,kx(80)-1,ky(80)
a,80,82,87,81,88,89
a,82,83,84,85,86,87

ldiv,13,.34
csys,0
wpcs,-1
kwpa,57
wpro,,-90
wpro,,,60
asel,,,,1
asbw,all
wpcs,-1
kwpa,14
wpof,,12
wpro,,-90
asbw,all

allsel
aovlap,all

!divide bottom slab rebar at radial locations
*dim,bsr,,4
dl5=27.4
bsr(1)=(7+7.5)/2*12+dl5,(14+15)/2*12+dl5,31*12+6-
9,435
asel,s,,,7
csys,0
wpcs,-1
wpro,,,-90
*do,i,1,4
 wpoff,,,bsr(i)
 asbw,all
 wpoff,,,-bsr(i)
*enddo

wpcs,-1
wpoff,kx(68),ky(68)
wpro,,,-90
wpro,,atan(ssli)
asbw,2
wpcs,-1
wpoff,kx(70),ky(70)
wpro,,,-90
wpro,,atan(sslo)
asbw,1
wpcs,-1
wpoff,kx(72),ky(72)
wpro,,,-90
wpro,,atan(sslo)
asbw,7

!divide top slab rebar at radial locations
*dim,tsr,,7
tsr(1)=kx(69),kx(35),kx(98),kx(71),kx(100),kx(102),kx(7
3)
asel,s,,,8
csys,0
```

E.18

```
wpcsys,-1
wprot,,,90
*do,i,1,7
 wpoff,,,tsr(i)
 asbw,all
 wpoff,,,-tsr(i)
*enddo

!divide wall rebar
*dim,wr,,4
wr(1)=10*12+19+h2,17*12,23*12+19+h2,h3-42
asel,s,,,15,16
csys,0
wpcsys,-1
wprot,,-90
kwpave,3
*do,i,1,4
 wpoff,,,wr(i)
 asbw,all
 wpoff,,,-wr(i)
*enddo

!divide dome rebar
*dim,dr,,7
dl6=32.9
dr(1)=7*12+3+dl6,12*12+6+dl6,22*12+6,(24+26.75)/2*1
2,26*12+2,29*12+6,28*12+dl6,
asel,s,,,18,28,10
csys,0
wpcs,-1
wpro,,,-90
kwpa,3
jdcr=h6-3-95*12
*do,i,1,7
 wpof,,jdcr+95*12*cos(asin(dr(i)/(95*12))),dr(i)
 wpro,,asin(dr(i)/(95*12))
 asbw,all
 wpro,,-asin(dr(i)/(95*12))
 wpof,,-(jdcr+95*12*cos(asin(dr(i)/(95*12)))),-dr(i)
*enddo

!divide bent bar, top of haunch
wpcsys,-1
kwpave,17
wpoff,48*cos(30)
wprot,,,-90
asel,s,,,29
asbw,all
allsel
l,40,39
asbl,28,127

allsel
nummrg,all
numcmp,all

!J-bolts
! 32-35 are tank wall stiffeners
*dim,jx,,35
*dim,jy,,35
*dim,jdeg,,35
jx(1)=479,479,479,479,479,479,479,479,479,479
```

```
jx(11)=479,479,479,479,479,479,473,462,450,432
jx(21)=412,391,369,347,324,299,272,241,206,165
jx(31)=107,479,479,479,479
jy(1)=19,43,67,91,115,139,163,187,211,235
jy(11)=259,283,307,331,355,379,402,424,442,460
jy(21)=474,486,496,504,511,515,518,522,525,527
jy(31)=529,89.5,89.5*2,89.5*3,89.5*4
jdeg(1)=90,90,90,90,90,90,90,90,90,90
jdeg(11)=90,90,90,90,90,90,75,55,45,40
jdeg(21)=35,30,25,20,15,10,9,8,7,6,5
jdeg(31)=1,90,90,90,90

csys
asel,,,,24,29,5
,a,,,42,46,4
,a,,,14,16,2
,a,,,19,21,2
,a,,,30,51,21
,a,,,45,49,2
,a,,,50,56,2
,a,,,60,62,2

*do,i,1,35
 wpcsys,-1
 wpave,-jx(i),jy(i)
 wprot,jdeg(i)
 wprot,,,90
 asbw,all
*enddo

!bottom anchors
lanch=5+3/16
ldiv,228,.14
kgen,2,38,,,0,lanch,0
a,12,268,269,38
allsel
aovlap,all

!flange of wall stiffeners - 6"
lsel,,,,175,246,71
,a,,,266,303,37
*do,i,32,35
 wpcsys,-1
 wpave,-jx(i),jy(i)
 wprot,jdeg(i)
 wprot,,,90
 wpoff,,,-6
 lsbw,all
*enddo
lsel,all

! dome stiffener (detail 9)
lang,16,51,90,.8
lsel,,,,414
lsum
lsel,all
*get,stang,line,,ixv,x
wpcs,-1
kwpa,51
wpro,,,-90
wpro,,acos(stang)
wpof,,,6
```

```
lsbw,324
asbl,106,414

! line for concentrated load
wpcs,-1
kwpa,1
wpro,,,-90
wpof,,,clr
lsbw,1

!Identify areas
!inside layer of rebar
asel,,loc,x,-485,-484
,u,,,33,34
,a,,,21,91,70
,a,,,30,100,70
,a,,,104,105
,a,,,102,110,8
,a,,,107,111,4
,a,,,19,62,43
,a,,,51,60,9
,a,,,112,116,2
,a,,,118,120,2
,a,,,50,56,2
,a,,,122,127,5
,a,,,47
cm,as1,area

!outside layer of rebar
asel,,loc,x,-496,-495
,a,,,18,64,46
,a,,,57,59
,a,,,61,63,2
,a,,,53,55,2
,a,,,28,43,15
cm,as2,area

!bottom layer of slab
asel,,,,1,2
,a,,,4,6
,a,,,11,13,2
,a,,,33
cm,as3,area

!top layer of slab
asel,,loc,y,-13,-11
cm,as4,area

!haunch
asel,s,,,32
cm,haunch,area

!concrete insulation
asel,s,,,3
cm,cinsul,area

!slab
asel,s,,,31
cm,slab,area

!haunch vertical steel
asel,s,,,9
```

```
cm,hvert,area

!haunch radial
asel,s,,,10
cm,hrad,area

!concrete
allsel
cmsel,u,hrad
cmsel,u,hvert
cmsel,u,slab
cmsel,u,cinsul
cmsel,u,haunch
cmsel,u,as4
cmsel,u,as3
cmsel,u,as2
cmsel,u,as1
cm,conc,area

allsel
save,pnnla,db
```

Input file: PNNLA2.mac

```
mat_liner=1
mat_conc=2
mat_rebar=3
mat_insul=4
mat_soil=5
mat_haunch=6

type_liner=1          !liner shells
type_tank=2           !tank concrete
type_haunch=3         !haunch concrete
type_slab=4           !slab concrete
type_rebar=5          !rebar
type_insul=6          !insulating concrete
type_soil=7           !soil

et,type_liner,181
et,type_tank,181
et,type_haunch,181
et,type_slab,181
et,type_rebar,181
et,type_insul,181
et,type_soil,181

et,type_liner+10,65
et,type_tank+10,65
et,type_haunch+10,65
et,type_slab+10,65
et,type_rebar+10,65
et,type_insul+10,65
et,type_soil+10,45

!define local element coordinate systems for rebar regions
cmsel,s,as1
cmsel,a,as2
cmsel,a,as3
cmsel,a,as4
cmsel,a,hrad
cmsel,a,hvert
*get,narea,area,,count
```

```
cm,atemp,area

*afun,deg
ics=100
*do,i,1,narea
 *get,ia,area,,num,min
 asel,s,,,ia
 lsla
 ksll
 csys,0
 *get,minx,kp,,mnloc,x
 *get,maxx,kp,,mxloc,x
 *get,miny,kp,,mnloc,y
 *get,maxy,kp,,mxloc,y
 theta=90
 *if,minx,ne,maxx,then
      theta=atan((maxy-miny)/(maxx-minx))
 *endif
 wpcsys,-1
 kwpave,all
 wprot,theta
 cswplan,ics,0
 aatt,mat_rebar,,type_rebar,ics
 cmsel,s,atemp
 asel,u,,,ia
 cm,atemp,area
 ics=ics+1
*enddo

!define spherical coordinate system for haunch, with
center at global origin
csys,0
wpcsys,-1
local,ics,2
asel,s,,,32
aatt,mat_conc,604,type_haunch,ics

!set real constants for rebar
csys,0
wpcsys,-1
!wall external
set_ry,-8,131,201,'as2'
set_ry,131,204,202,'as2'
set_ry,204,287,203,'as2'
set_ry,287,339,204,'as2'
set_ry,339,382,205,'as2'

!wall internal
csys,0
wpcsys,-1
set_ry,-8,131,206,'as1'
set_ry,131,204,207,'as1'
set_ry,204,287,208,'as1'
set_ry,287,339,209,'as1'
set_ry,339,382,210,'as1'

!slab bottom
csys,0
wpcsys,-1
set_rx,-75,0,101,'as3'
set_rx,-115,-75,102,'as3'
set_rx,-202,-115,103,'as3'
```

```
set_rx,-350,-202,104,'as3'
set_rx,-369,-350,105,'as3'
set_rx,-435,-369,106,'as3'
set_rx,-442,-435,107,'as3'
set_rx,-531,-442,108,'as3'

!slab top
csys,0
wpcsys,-1
set_rx,-75,0,111,'as4'
set_rx,-115,-75,112,'as4'
set_rx,-202,-115,113,'as4'
set_rx,-350,-202,114,'as4'
set_rx,-369,-350,115,'as4'
set_rx,-435,-369,116,'as4'
set_rx,-442,-435,117,'as4'
set_rx,-531,-442,118,'as4'

!dome external
csys,0
wpcsys,-1
set_rx,-120,0,301,'as2'
set_rx,-183,-120,302,'as2'
set_rx,-270,-183,303,'as2'
set_rx,-305,-270,304,'as2'
set_rx,-314,-305,305,'as2'
set_rx,-354,-314,306,'as2'
set_rx,-369,-354,307,'as2'
set_rx,-400,-369,308,'as2'

!dome internal
csys,0
wpcsys,-1
set_rx,-120,0,301,'as1'
set_rx,-183,-120,302,'as1'
set_rx,-270,-183,303,'as1'
set_rx,-305,-270,304,'as1'
set_rx,-314,-305,305,'as1'
set_rx,-354,-314,306,'as1'
set_rx,-369,-354,307,'as1'
set_rx,-400,-369,308,'as1'

!haunch external
csys,5
wpcs,-1
cmse,s,as2
asel,r,loc,x,396,450
set_real,401
cmse,s,as2
asel,r,loc,x,450,504
,r,loc,z,381,999
set_real,402
cmse,s,as2
asel,r,loc,z,408,450
set_real,403
cmse,s,as2
asel,r,loc,z,372,410                    !Problem??
set_real,404

!haunch_internal
cmse,,as1
set_ry,381,408,405,'as1'
```

```
set_ry,408,488,406,'as1'

! Split haunch vertical at top of radial intersection
lsel,all
ksel,all
asel,s,,,9
ldiv,82,,.47
l,278,87
*get,ics,area,9,attr,esys
asbl,9,418
cm,hvert,area
aatt,mat_rebar,,type_rebar,ics

!haunch middle (vertical)
asel,,,,67
set_real,500              !Lower
asel,,,,65
set_real,501              !Upper
!haunch middle (radial)
asel,s,,,10
set_real,502

!insulating concrete
asel,s,,,3
aatt,mat_insul,600,type_insul,0

!haunch concrete
asel,s,,,32
aatt,mat_haunch,503,type_haunch,ics

allsel
asel,u,mat,,mat_insul
asel,u,mat,,mat_rebar
asel,u,mat,,mat_haunch
aatt,mat_conc,700,type_tank,0
cm,atemp,area
asel,r,loc,y,-999,-8.125
aatt,mat_conc,700,type_slab,0
cmsel,s,atemp
asel,u,type,,type_slab
aatt,mat_conc,700,type_tank,0

asel,s,,,27        Outer cover haunch
l,39,18
asbl,27,419
aatt,mat_conc,700,type_tank,0

allsel
save,pnnla2,db
```

Input file: PNNLA3.mac

```
!identify jbolt lines
!***  Remove jbolts from wall 5/6/04
lsel,,,,315,322,7
,a,,,318,327,9
,a,,,92,332,240
,a,,,326,337,11
,a,,,335,342,7
,a,,,209,349,140
,a,,,345,375,5
,a,,,354,379,5
,a,,,382
```

```
cm,line_bolt,line

lsel,,,,229,389,160
,a,,,310,394,84
,a,,,399,407,8
,a,,,287,288
,a,,,413
cm,line_wstiff,line

lsel,,,,414,415
cm,line_hstiff,line

lsel,,,,3,9,6
,a,,,14,19,5
,a,,,330
,a,,,58,59
,a,,,339,341,2
,a,,,348,373,5
,a,,,380,381
,a,,,385
cm,line_prim,line

ksel,,loc,x,-480
,r,loc,y,,382
lslk,,1
lsel,a,,,16,17
,a,,,21,22
,a,,,25,27,2
,a,,,314,323,9
,a,,,96
,a,,,291,303,12
```

```
cm,line_secon,line

lsel,s,,,309
,a,,,406
cm,line_botanch,line

allsel

save,pnnla3,db
```

Input file: PNNLA4.mac

```
!copy areas for overlapping with soil
cm,a_orig,area
agen,2,all
cmsel,u,a_orig
cm,a_new,area

csys,0
ksel,s,loc,x,0
cm,ktemp,kp
*get,ymx,kp,,mxloc,y
*get,ymn,kp,,mnloc,y
ksel,r,loc,y,ymx
*get,iktop,kp,,num,min
cmsel,s,ktemp
ksel,r,loc,y,ymn
*get,ikbot,kp,,num,min

htop=12
```

```
radsoil=550
depthsoil=60
csys,0
wpcsys,-1
asel,none
rectng,-radsoil,0,ymn-depthsoil,ymx+htop
cm,as0,area
allsel
asba,as0,a_new
asel,s,,,283
adele,all,,,1
asel,s,,,282
cm,soil,area
aatt,mat_soil,1,type_soil

/input,mesh_size,mac

!***
!***   Clean up mesh 4/1/03
!***

lesi,385,,,20
,380,,,14
,89,,,76
,339,,,4
,246,,,1
,129,,,19
,175,,,3
,177,,,1
,178,,,1
,171,,,2
,172,,,2
,34,,,9
asel,s,type,,type_rebar
esize,eesize
amesh,all
acle,10
amap,10,82,84,85,87
asel,invert
asel,u,type,,type_soil
esize,eesize
amesh,all
asel,s,type,,type_soil
asel,a,mat,,mat_conc
lsla
ksll
nummrg,kp

asel,s,mat,,mat_soil
smrtsize,8
lsel,s,,,832                !vertical line above dome center
lesize,all,,,4
lsel,s,,,833                !vertical line below dome center
lesize,all,,,8
esize,soil_size  !20
amesh,all

extopt,esize,1
type,17
vrotat,all,,,,,,ikbot,iktop,swp_th,1

asel,s,type,,type_slab
```

E.27

```
asel,a,type,,type_insul
cm,atemp,area
agen,2,all
cm,aaa,area
cmsel,s,atemp
aclear,all
adele,all,,,1

allsel
aslv,u
*get,na,area,,count
cm,atemp,area
*do,i,1,na
 *get,ia,area,,num,min
 asel,s,,,ia
 *get,imat,area,ia,attr,mat
 *get,ireal,area,ia,attr,real
 *get,itype,area,ia,attr,type
 *get,isys,area,ia,attr,esys
 mat,imat
 real,ireal
 type,itype+10
 esys,isys
 ksel,all
 vrotat,ia,,,,,,ikbot,iktop,swp_th,1
 cmsel,s,atemp
 asel,u,,,ia
 cm,atemp,area
*enddo

allsel
aclear,all
save,pnnla4,db
```

Input file: PNNLA5.mac

```
vsel,s,mat,,1
cm,vtemp,volu
vgen,2,all
cm,vvv,volu
cmsel,s,vtemp
vclear,all
vdele,all,,,1
cmsel,s,vvv
eslv
emodif,all,mat,mat_soil

!rotate all nodes to cylindrical coordinate system (22)
csys,0
wpcsys,-1
wprot,,-90
cswplan,22,1
allsel
nrotate,all

csys,0
!merge slab/rebar nodes/kps
vsel,s,type,,type_rebar+10
vsel,r,loc,y,-999,-11
vsel,a,type,,type_slab+10
vsel,u,mat,,1
eslv
nsle
```

```
aslv
lsla
ksll
nummrg,node
nummrg,kp

!merge tank/rebar nodes/kps
vsel,s,type,,type_rebar+10
vsel,r,loc,y,-8,999
vsel,a,type,,type_tank+10
vsel,a,type,,type_haunch+10
vsel,u,mat,,1
aslv
lsla
ksll
nsla,,1
nummrg,node
nummrg,kp

!couple soil to concrete exterior
esel,s,mat,,mat_soil
nsle
ksln
lslk,,1
asll,,1
cm,asoil,area
vsel,s,type,,type_tank+10
aslv
asel,r,ext
cm,atank,area
vsel,s,type,,type_slab+10
aslv
asel,r,ext
cm,aslab,area
vsel,s,type,,type_insul+10
aslv
cm,ainsul,area

!top of dome
csys,0
cmsel,s,atank
cmsel,a,asoil
asel,r,loc,y,452,999
lsla
nsla,,1
cpintf,uz,.1

!side of tank
cmsel,s,atank
cmsel,a,asoil
asel,r,loc,y,-8.125,452
lsla
nsla,,1
cpintf,ux,.1

!top of slab
cmsel,s,aslab
cmsel,a,asoil
asel,r,loc,y,-6.7,-6.6
lsla
nsla,,1
cpintf,uz,.1
```

```
!side of slab
cmsel,s,aslab
cmsel,a,asoil
asel,r,loc,y,-31,-6.7
asel,r,loc,x,-999,-529
lsla
nsla,,1
cpintf,ux,.1

!bottom of slab
cmsel,s,aslab
cmsel,a,asoil
asel,r,loc,x,-530,0
asel,r,loc,y,-999,-18.5
lsla
nsla,,1
cpintf,uz,.1

!couple top of slab / bottom of wall
cmsel,s,aslab
cmsel,a,atank
lsla
nsla,,1
cpintf,uz,.1

!couple top of slab / bottom of insulating concrete
vsel,s,mat,,mat_insul
cm,vtemp,volu
vgen,2,all
cm,volu_insul,volu
cmsel,s,vtemp
vclear,all
vdele,all,,,1
cmsel,s,volu_insul
aslv
cm,ainsul,area
cmsel,s,aslab
cmsel,a,ainsul
lsla
nsla,,1
cpintf,uz,.1

save,pnnla5,db
```

Input file: PNNLA6.mac

```
!***  mesh J-bolt @ liner w/separate node 5/6/04

!***  Use mesh200 for J-bolts  4/1/04
!***   redefine as beam188 in set_slicea.mac
resu,pnnla5,db
!generate J-bolts
type_bolt=20
et,type_bolt,200,2
mat,mat_liner
type,type_bolt
csys,0
cmsel,s,line_bolt
csys,11
lsel,r,loc,x,480,483
lgen,2,all,,,,,,3000
ksll
```

```
ksel,r,loc,x,481,486
numm,kp
cmse,,line_bolt
lsel,u,loc,x,480,483
,a,,,423,435
lmesh,all
csys

!generate studs
type_stud=21
et,type_stud,4
area_stud=pi*.5**2/4
iy=pi*.5**4/64
iz=iy
ty=.5
tz=.5
r,30,area_stud,iy,iz,ty,tz
cmsel,s,line_botanch
real,30
mat,mat_liner
type,type_stud
lmesh,all

!generate wall base plate
asel,s,,,214
,a,,,706
,a,,,913,918,5
,a,,,934
cm,baseplate,area
type_baseplate=22
et,type_baseplate,63
r,40,.375
mat,mat_liner
type,type_baseplate
real,40
amesh,all

!generate confining ring below 12" secondary liner fillet
ksel,s,loc,x,-480-.01,-480+.01
ksel,r,loc,y,-8.2,6.9
lslk,,1
asll
asel,u,loc,z,0
cm,confineplate,area
type_confine=23
et,type_confine,63
r,41,3/16
type,type_confine
real,41
mat,mat_liner
amesh,all

!generate confining ring for insulating concrete
csys,0
ksel,s,loc,x,-447
lslk,,1
asll,,1
cm,confinering,area
type_confine=23
type,type_confine
real,41
mat,mat_liner
```

```
amesh,all

!generate construction stiffeners
cmsel,s,line_wstiff
asll
asel,u,loc,z,0
cm,stiff_area,area
type_stiff=24
et,type_stiff,63
type,type_stiff
r,42,.5
real,42
mat,mat_line
amesh,all

!generate detail #9
cmse,,line_hstiff
asll
asel,u,loc,z,0
cm,detail9,area
type_anchor=25
et,type_anchor,63
type,type_anchor
r,43,.375*1.1
real,43
mat,mat_liner
amesh,all

allsel
save,pnnla6,db
```

Input file: PNNLA7.mac

```
!primary liner
allsel
aslv
lsla
cmsel,s,line_prim
lsel,a,,,34
cm,ltemp,line

asll
asel,u,loc,z,0
ksll
nummrg,kp
cm,line_prim,line
cm,area_prim,area
! Reverse normals - dome
asel,r,loc,y,459,999
arev,all
asel,none
ksel,s,loc,x,0
ksel,r,loc,y,ymx
*get,iktop,kp,,num,min
ksel,s,loc,x,0
ksel,r,loc,y,ymn
*get,ikbot,kp,,num,min
ksel,all
cmsel,s,ltemp
cmsel,s,area_prim
lsla,u
arotat,all,,,,,,ikbot,iktop,swp_th,1
```

```
lsla
ksll
nummrg,kp
aatt,mat_liner,,type_liner
esize,4
smrt,off
lsel,s,,,9,436,427!radiused part of primary liner
lesi,all,,,8,,1
lsel,s,,,440,441
lesize,all,,,1,,1
amesh,all

cm,atemp,area
agen,2,all
cm,area_liner_prim,area
cmsel,s,atemp
aclear,all
vsel,all
aslv,u
adele,all,,,1

r,50,r50
r,51,r51
r,52,r52
r,53,r53
r,54,r54
r,55,r55

!1" lid at tank bottom
cmsel,s,area_liner_prim
esla
cm,etemp,elem
nsla,,1
cm,ntemp,node
nsel,r,loc,x,-24,0
nsel,r,loc,y,-999,10
esln
cmsel,r,etemp
emodif,all,real,50

!3/8" bottom (on top of insulating concrete)
cmsel,s,ntemp
nsel,r,loc,x,-450+48,-24
nsel,r,loc,y,-999,10
esln
cmsel,r,etemp
emodif,all,real,51

!7/8" at fillet
cmsel,s,ntemp
nsel,r,loc,x,-450,-450+48
nsel,r,loc,y,-999,36.89
esln
cmsel,r,etemp
emodif,all,real,52

!3/4" vertical run
cmsel,s,ntemp
nsel,r,loc,x,-450
nsel,r,loc,y,36.88,144.89
esln
cmsel,r,etemp
```

```
emodif,all,real,53

!1/2" vertical run
cmsel,s,ntemp
nsel,r,loc,x,-450
nsel,r,loc,y,144.88,381.5
esln
cmsel,r,etemp
emodif,all,real,54

!3/8" upper reaches of liner
cmsel,s,ntemp
nsel,r,loc,x,-450,-72.1
nsel,r,loc,y,381.6,999
esln
cmsel,r,etemp
emodif,all,real,51

!1/2" at top/center
cmsel,s,ntemp
nsel,r,loc,x,-72,0
nsel,r,loc,y,381.6,999
esln
cmsel,r,etemp
emodif,all,real,54

!couple vertical displacements at liner bottom
!(first rotate the shell nodes)
esel,s,type,,type_liner
nsle
csys,22
nrotate,all
csys,0
asel,s,loc,y,0
nsla,,1
cpintf,uz,.1
cm,liner_insul_cp_z,node

allsel
save,pnnla7,db
```

Input file: PNNLA8.mac

```
!create shell elements for secondary liner
cmsel,s,line_secon
asll
asel,u,loc,z,0
cm,atemp,area
! Reverse normals - upper section
asel,r,loc,y,381,999
arev,all
lsel,,,,21,22
,a,,,25
arotat,all,,,,,,ikbot,iktop,swp_th,1
cmsel,a,atemp
asel,a,,,27
cm,area_secon,area
lsla
ksll
nummrg,kp

lesi,437,,,1
```

```
,438,,,1
,9,,,6
,22,,,6
aatt,mat_liner,55,type_liner
amesh,all

cm,atemp,area
agen,2,all
cm,area_secon,area
cmsel,s,atemp
aclear,all
aslv,u
adele,all,,,1

ksel,s,loc,x,0
ksel,r,loc,y,ymx
*get,iktop,kp,,num,min
ksel,s,loc,x,0
ksel,r,loc,y,ymn
*get,ikbot,kp,,num,min
ksel,all

!couple vertical displacements at liner bottom
!(first rotate the shell nodes)
esel,s,type,,type_liner
nsle
csys,22
nrotate,all

csys,0
```

```
!couple shell horizontal displacements to sidewall

esel,s,type,,type_liner
nsle
cm,ntemp,node
esel,s,mat,,mat_conc
nsle
cmsel,a,ntemp
cm,ntemp,node
nsel,r,loc,y,-2,460
cpintf,ux,.1
cm,liner_wall_cp_x,node

!couple shell vertical displacement to dome
cmsel,s,ntemp
nsel,r,loc,y,460,999
cpintf,uz,.1
cm,liner_dome_cp_z,node

!merge secondary liner nodes with slab top nodes
asel,,loc,y,-8.125
,r,loc,x,-465,1
lsla
nsll,,1
cpdele,all,all
cpintf,uz,.1

allsel
save,pnnla8,db
```

Input file: PNNLA9.mac

```
!*** Do not common node intersection of
!*** primary & secondary liner JED 3/19/04

allsel
mpdele,all,all
tbdele,all,all
set_materials
set_options

acel,0,1,0

allsel

!merge coincident nodes between liners and
jbolts/studs/anchors
esel,s,type,,type_bolt
esel,a,type,,type_stiff
esel,a,type,,type_anchor
esel,a,type,,type_stud
esel,a,type,,type_liner
nsle,,1
nsel,u,,,22789,22790       !*** 3/19/04
nummrg,node

set_soil

allsel
ddele,all,all

!contrain boundaries
csys,0
nsel,s,loc,x,0
d,all,ux,0
d,all,uy,0

allsel
*get,xmn,node,,mnloc,x
*get,ymn,node,,mnloc,y
*get,ymx,node,,mxloc,y

nsel,s,loc,y,ymn
d,all,ux,0,,,,uy,uz

ksel,s,loc,x,xmn
ksel,r,loc,z,0
lslk,,1
asll
asel,u,loc,z,0
nsla,,1
d,all,ux,0
d,all,uy,0

asel,s,loc,y,ymn
nsla,,1
d,all,ux,0,,,,uy,uz

csys,22
nsel,s,loc,y,180-.01,180+.01
nsel,a,loc,y,180+swp_th-.01,180+swp_th+.01
d,all,uy,0
allsel
```

```
save,pnnla9,db
```

Input file: set_areas_slice.mac

```
asel,,,,150,161
,a,,,177,179,2
,a,,,184,212,28
,a,,,224,226,2
cm,area_prim,area

vsel,,,,1,199,,1
asel,inve
cmse,u,area_prim
cm,area_secon,area

cmsel,a,area_prim
nsla,,1
esln
sfdele,all,all
sfedele,all,all,all

asel,s,,,239
nsla,,1
esln
arev,all

cmse,,avert
,a,ahorz
cm,asoil,area

asel,,,,314,316
,a,,,700
,a,,,196
,a,,,221,261,40
,a,,,978,984
cm,aconc_soil,area

asel,s,,,993,994
cm,slab_top,area

asel,,,,929
,a,,,552,563,11
,a,,,870,876,6
,a,,,583,593,10
,a,,,605,625,20
,a,,,881,887,6
,a,,,636,646,10
,a,,,892,898,6
,a,,,671,677,6
,a,,,651,693,42
,a,,,641,656,15
,a,,,231,238,7
,a,,,710
,a,,,333
,a,,,243,244
,a,,,190,191
,a,,,723,733,10
,a,,,756,762,6
,a,,,784,796,12
,a,,,806,818,12
,a,,,828,839,11
,a,,,853,864,11
,a,,,844
```

```
cm,aconc_shell,area

asel,,,,106,143,37
cm,area_insul_top,area

asel,s,,,27
cm,area_insul_bot,area
```

Input file: set_backfill.mac

```
!***
!***Dilation angle 8   6/4/04
!*** Add materials for load factor restart 8/2/03
!***  JED mod 4/1/03
!***   Define backfill/overburden
!***
max_mat=max_mat+1
cmse,,soil_elem
nsle
hsub=top_elev-arg2-h2+24
rsub=-(68*12+hsub/1.5)
nsel,r,loc,y,top_elev-arg1,top_elev-arg2
,r,loc,x,rsub,0
esln
esel,r,mat,,max_mat
emod,all,mat,max_mat+20

soil_ex=arg3                  !elastic modulus [psi]
soil_prxy=arg4                !Poisson ratio
soil_alpx=0                   !thermal expansion
coefficient [me/F]
soil_cohesion=1               !drucker-prager constant
(assume small number) [psi]
soil_friction=35          !internal friction angle [deg]
soil_dilat=8                  !dilatancy angle [deg]

soil_alpx=soil_alpx*1e-6      !in/in/F
soil_dens=b_gam/1728          !lb/in^3

mp,ex,max_mat+20,soil_ex
mp,dens,max_mat+20,soil_dens
mp,prxy,max_mat+20,soil_prxy
mp,alpx,max_mat+20,soil_alpx
tb,dp,max_mat+20
tbdata,1,soil_cohesion,soil_friction,soil_dilat

!*** materials max_mat+70 for load factor restart

mp,ex,max_mat+70,soil_ex
mp,dens,max_mat+70,soil_dens*1.7/1.4
mp,prxy,max_mat+70,soil_prxy
mp,alpx,max_mat+70,soil_alpx
tb,dp,max_mat+70
tbdata,1,soil_cohesion,soil_friction,soil_dilat
```

Input file: set_csys.mac

```
*get,ia,area,,num,min
*get,iareal,area,ia,attr,real
*get,iamat,area,ia,attr,mat
*get,iatype,area,ia,attr,type
aatt,iamat,iareal,iatype,arg1
```

Input file: set_esys.mac

```
!***
!***  Set wall & dome rebar to material 3   6/4/04
!***

/prep7
!define reinforced concrete real constants

!---Create local coordinate systems for esys
!--spherical 1
wpcsys,-1,0                  !spherical
kwpave,1
wpoff,,-1260
cswpla,200,2

wpcsys,-1,0                  !spherical
kwpave,1
wpoff,,-892
cswpla,201,2

csys,0                       !ellipcal coordinate
wpcsys,-1
rat=40/15
k,10000,0,h3,0
kwpave,10000
wprot,90
cswplan,202,2,rat,rat

esel,s,real,,100,118  !slab
esel,r,type,,15
emodif,all,esys,22

esel,s,real,,200,210         !vertical wall
esel,r,type,,15
emodif,all,esys,22

esel,s,real,,300,308    !inner exterior dome
esel,r,type,,15
nsle
csys,22
nsel,r,loc,x,0,170
esln
esel,r,type,,15
emodif,all,esys,200

esel,s,real,,300,308    !outer exterior dome
esel,r,type,,15
nsle
csys,22
nsel,r,loc,x,170,9999
esln
esel,r,type,,15
emodif,all,esys,201

esel,s,real,,401,402         !exterior haunch
esel,r,type,,15
emodif,all,esys,201

esel,s,real,,403,404         !vertical haunch
esel,r,type,,15
emodif,all,esys,22
```

```
esel,s,real,,405,406        !interior haunch
esel,r,type,,15
emodif,all,esys,202

esel,s,real,,500,501        !vertical mid haunch
esel,r,type,,15
emodif,all,esys,22

esel,s,real,,502   !spherical mid haunch
esel,r,type,,15
emodif,all,esys,201

esel,s,real,,503   !tie bar haunch
emodif,all,esys,ics


! Slab bottom
r,101,6,.0256,,,6,.0256           ! Center to 6'3"
rmor,90,,,,90,90
r,102,6,.0258,,,6,.0256           ! 6'3" to 7'6"+ld
rmor,90,,,,90,90
r,103,6,.0316,,,6,.0256           ! 7'6"+ld to 14'6"+ld
rmor,90,,,,90,90
r,104,6,.0360,,,6,.0256           ! 14'6"+ld to 29'2"
rmor,90,,,,90,90
r,105,6,.0326,,,6,.0256           ! 29'2" to 30'9"
rmor,90,,,,90,90
r,106,6,.0293,,,6,.0256           ! 30'9" to 36'3"
rmor,90,,,,90,90
r,107,6,.0267,,,6,.0552           ! 36'3" to 37'
rmor,90,,,,90,90
r,108,6,.1016,,,6,.0552           ! 37' to OD
rmor,90,,,,90,90

! Slab top
r,111,6,.0256,,,6,.0256           ! Center to 6'3"
rmor,90,,,,90,90
r,112,6,.0242,,,6,.0256           ! 6'3" to 7'6"+ld
rmor,90,,,,90,90
r,113,6,.0330,,,6,.0256           ! 7'6"+ld to 14'6"+ld
rmor,90,,,,90,90
r,114,6,.0377,,,6,.0256           ! 14'6"+ld to 29'2"
rmor,90,,,,90,90
r,115,6,.0269,,,6,.0256           ! 29'2" to 30'9"
rmor,90,,,,90,90
r,116,6,.0313,,,6,.0256           ! 30'9" to 36'3"
rmor,90,,,,90,90
r,117,6,.0284,,,6,.0552           ! 36'3" to 37'
rmor,90,,,,90,90
r,118,6,.0259,,,6,.0552           ! 37' to OD
rmor,90,,,,90,90


! Wall external
r,201,,,,,3,.0982         ! Base to 10'3" + 1/2 splice
rmor,90,,3,.0368,90,90
r,202,,,,,3,.0982         ! 10'3" to 17'
rmor,90,,3,.0491,90,90
r,203,,,,,3,.0655         ! 17' to 23'3" + 1/2 splice
rmor,90,,3,.0491,90,90
r,204,,,,,3,.0655         ! 23'3" to 28'3-1/2"
rmor,90,,3,.0655,90,90
r,205,,,,,3,.0655         ! 28'3-1/2" to tangent height
```

```
rmor,90,,3,.0655,90,90

! Wall internal
r,206,,,,,3,.0982          ! Base to 10'3" + 1/2 splice
rmor,90,,3,.0368,90,90
r,207,,,,,3,.0982          ! 10'3" to 17'
rmor,90,,3,.0491,90,90
r,208,,,,,3,.0655          ! 17' to 23'3" + 1/2 splice
rmor,90,,3,.0491,90,90
r,209,,,,,3,.0655          ! 23'3" to 28'3-1/2"
rmor,90,,3,.0655,90,90
r,210,,,,,3,.0655          ! 28'3-1/2" to tangent height
rmor,90,,3,.0655,90,90

! Dome top & bottom
r,301,,,,,3,.0453          ! Center to 7'3"
rmor,90,,3,.0368,90,90
r,302,,,,,3,.0490          ! 7'3" to 12'6" +
rmor,90,,3,.0368,90,90
r,303,,,,,3,.0661          ! 12'6" to 22'9"
rmor,90,,3,.0368,90,90
r,304,,,,,3,.0496          ! 22'9" to 25'4-1/2"
rmor,90,,3,.1309,90,90
r,305,,,,,3,.1399          ! 25'4-1/2" to 26'2"
rmor,90,,3,.1309,90,90
r,306,,,,,3,.1300          ! 26'2" to 29'9
rmor,90,,3,.1657,90,90
r,307,,,,,3,.1197          ! 28' to 29'6"
rmor,90,,3,.2485,90,90
r,308,,,,,3,.1139          ! 29'6" to 32'6"
rmor,90,,3,.2485,90,90

! Haunch external
!   Dome (csys,201)
r,401,,,,,3,.2209          ! 33'3" to 37'6"
rmor,90,,3,.1534,90,90
r,402,,,,,3,.2209          ! 37'6" to 41'4"
rmor,90,,3,.1375,90,90
!   Wall (csys,22)
r,403,,,,,3,.2485          ! Height: 34' to corner
rmor,90,,3,.2045,90,90
r,404,,,,,3,.1309          ! Height: tangent to 34'
rmor,90,,3,.2700,90,90

! Haunch internal
!  (csys,202)
r,405,,,,,3,.1309          ! Height: tangent to 34'
rmor,90,,3,.1309,90,90
r,406,,,,,3,.2209          ! 33'3" radius to 34' height
rmor,90,,3,.1489,90,90

!haunch middle
!   (csys,202)
r,502,3,.0007,,,3,.0261          ! 33'3" to vertical
rmor,90,,3,.2209,90,90
!   (csys,22)
r,500,3,.0007,,,3,.1243          ! lower vertical
rmor,90,,3,.0236,90,90
r,501,3,.0007,,,3,.1243          ! upper vertical
rmor,90,,3,.0109,90,90

!haunch ties
```

```
r,503,3,.0006
rmore,90,,,,90,90

!secondary liner above 357.5"
r,56,r56
esel,s,real,,55
nsle,,1
csys,0
nsel,r,loc,y,357.5,99999
esln,,1
esel,r,type,,1
emodif,all,real,56
```

Input file: set_mat.mac

```
*get,ia,area,,num,min
*get,iareal,area,ia,attr,real
*get,iatype,area,ia,attr,type
*get,iacsys,area,ia,attr,esys
aatt,arg1,iareal,iatype,iacsys
```

Input file: set_materials.mac

```
!***
!***6/7/04  Add 205F & 215F degraded concrete
!***6/4/04  MISO rebar (mats 3 & 6)
!***10/9/03 Fill out temperature dependent steel modulus
table
!***7/23/03 Elastic insulating concrete (no cracking)
!***6/17/03 Correct alpx,mat_liner
!***
!***      5/14/03
!***Add 6 concrete materials: mats 21 - 26
!***   Constant (degraded) properties @
230,250,270,290,310,330
!***  to be used after t=3+15+330 days
!***
!***Remove concrete crushing 5/5/03
!***
!***  Temperature dependent Materials
!***    Best estimate = mean values
!***     All steel elastic
!***      Run 2 (nocreep)  4/16/03
!***
!specify all material properties
/prep7

![1]                  steel (for liner, jbolts, studs, anchors,
bearing plates)
steel_alpx=steel_alpx*1e-6                    !in/in/F
steel_dens=steel_gamma/1728                   !lb/in^3

mpte
mpte,1,50,70,100,125,150,175
mpte,7,200,225,250,275,300,325
mpte,13,350
mpda,ex,mat_liner,1,29.5e6,29.5e6,29.34e6,29.20e6,29.0
7e6,28.93e6
mpda,ex,mat_liner,7,28.8e6,28.68e6,28.55e6,28.43e6,28.
3e6,28.15e6
mpda,ex,mat_liner,13,28.0e6
mp,dens,mat_liner,steel_dens
mp,prxy,mat_liner,steel_prxy
```

```
mpda,alpx,mat_liner,1,5.73e-6,5.73e-6,5.73e-6,5.82e-
6,5.91e-6,6.0e-6
mpda,alpx,mat_liner,7,6.09e-6,6.18e-6,6.27e-6,6.35e-
6,6.43e-6,6.51e-6
mpda,alpx,mat_liner,13,6.59e-6
tb,biso,mat_liner
tbdata,1,steel_yield,steel_tan*steel_ex

![2]          structural concrete
conc_alpx=conc_alpx*1e-6          !in/in/F
conc_dens=conc_gamma/1728         !lb/in^3

mp,ex,mat_conc,7.434e6,-30.09e3,71.16,-.0709
mpda,ex,mat_conc,1,5.083e6,5.083e6,5.083e6
mp,dens,mat_conc,conc_dens
mp,prxy,mat_conc,conc_prxy
mp,alpx,mat_conc,conc_alpx
tb,concr,mat_conc,5
tbte,50,1
tbda,1,.1,.98,519,-1
tbte,200,2
tbda,1,.1,.98,519,-1
tbte,225,3
tbda,1,.1,.98,427,-1
tbte,250,4
tbda,1,.1,.98,335,-1
tbte,350,5
tbda,1,.1,.98,335,-1

tb,creep,mat_conc
tbda,1,.2545e-6,1,-.838,320,,1

![21]   degraded structural concrete (205F)
mp,ex,21,3.652e6
,dens,21,conc_dens
,prxy,21,conc_prxy
,alpx,21,conc_alpx
tb,concr,21
tbda,1,.1,.98,501,-1
tb,creep,21
tbda,1,.2545e-6,1,-.838,320,,1

![22]   degraded structural concrete (215F)
mp,ex,22,3.557e6
,dens,22,conc_dens
,prxy,22,conc_prxy
,alpx,22,conc_alpx
tb,concr,22
tbda,1,.1,.98,465,-1
tb,creep,22
tbda,1,.2545e-6,1,-.838,320,,1

![23]   degraded structural concrete (225F)
mp,ex,23,3.467e6
,dens,23,conc_dens
,prxy,23,conc_prxy
,alpx,23,conc_alpx
tb,concr,23
tbda,1,.1,.98,427,-1
tb,creep,23
tbda,1,.2545e-6,1,-.838,320,,1
```

E.43

```
![24]   degraded structural concrete (235F)
mp,ex,24,3.380e6
,dens,24,conc_dens
,prxy,24,conc_prxy
,alpx,24,conc_alpx
tb,concr,24
tbda,1,.1,.98,390,-1
tb,creep,24
tbda,1,.2545e-6,1,-.838,320,,1

![25]   degraded structural concrete (245F)
mp,ex,25,3.297e6
,dens,25,conc_dens
,prxy,25,conc_prxy
,alpx,25,conc_alpx
tb,concr,25
tbda,1,.1,.98,354,-1
tb,creep,25
tbda,1,.2545e-6,1,-.838,320,,1

![26]   degraded structural concrete (255F)
mp,ex,26,3.217e6
,dens,26,conc_dens
,prxy,26,conc_prxy
,alpx,26,conc_alpx
tb,concr,26
tbda,1,.1,.98,335,-1
tb,creep,26
tbda,1,.2545e-6,1,-.838,320,,1

![27]   degraded structural concrete (265F)
mp,ex,27,3.141e6
,dens,27,conc_dens
,prxy,27,conc_prxy
,alpx,27,conc_alpx
tb,concr,27
tbda,1,.1,.98,335,-1
tb,creep,27
tbda,1,.2545e-6,1,-.838,320,,1

![28]   degraded structural concrete (275F)
mp,ex,28,3.067e6
,dens,28,conc_dens
,prxy,28,conc_prxy
,alpx,28,conc_alpx
tb,concr,28
tbda,1,.1,.98,335,-1
tb,creep,28
tbda,1,.2545e-6,1,-.838,320,,1

![29]   degraded structural concrete (285F)
mp,ex,29,2.996e6
,dens,29,conc_dens
,prxy,29,conc_prxy
,alpx,29,conc_alpx
tb,concr,29
tbda,1,.1,.98,335,-1
tb,creep,29
tbda,1,.2545e-6,1,-.838,320,,1

![30]   degraded structural concrete (295F)
mp,ex,30,2.927e6
```

```
,dens,30,conc_dens
,prxy,30,conc_prxy
,alpx,30,conc_alpx
tb,concr,30
tbda,1,.1,.98,335,-1
tb,creep,30
tbda,1,.2545e-6,1,-.838,320,,1

![31]      degraded structural concrete (305F)
mp,ex,31,2.860e6
,dens,31,conc_dens
,prxy,31,conc_prxy
,alpx,31,conc_alpx
tb,concr,31
tbda,1,.1,.98,335,-1
tb,creep,31
tbda,1,.2545e-6,1,-.838,320,,1

![32]      degraded structural concrete (315F)
mp,ex,32,2.796e6
,dens,32,conc_dens
,prxy,32,conc_prxy
,alpx,32,conc_alpx
tb,concr,32
tbda,1,.1,.98,335,-1
tb,creep,32
tbda,1,.2545e-6,1,-.838,320,,1

![33]      degraded structural concrete (325F)
mp,ex,33,2.734e6
,dens,33,conc_dens
,prxy,33,conc_prxy
,alpx,33,conc_alpx
tb,concr,33
tbda,1,.1,.98,335,-1
tb,creep,33
tbda,1,.2545e-6,1,-.838,320,,1

![34]      degraded structural concrete (335F)
mp,ex,34,2.673e6
,dens,34,conc_dens
,prxy,34,conc_prxy
,alpx,34,conc_alpx
tb,concr,34
tbda,1,.1,.98,335,-1
tb,creep,34
tbda,1,.2545e-6,1,-.838,320,,1

![35]      degraded structural concrete (345F)
mp,ex,35,2.615e6
,dens,35,conc_dens
,prxy,35,conc_prxy
,alpx,35,conc_alpx
tb,concr,35
tbda,1,.1,.98,335,-1
tb,creep,35
tbda,1,.2545e-6,1,-.838,320,,1

![3]              rebar
rebar_alpx=rebar_alpx*1e-6             !in/in/F
rebar_dens=rebar_gamma/1728            !lb-sec^2/in^4
```

```
mp,ex,mat_rebar,rebar_ex
mp,dens,mat_rebar,rebar_dens
mp,prxy,mat_rebar,rebar_prxy
mp,alpx,mat_rebar,rebar_alpx
tb,miso,mat_rebar,4,4
tbte,100,1
tbpt,,2069e-6,60000
,,3770e-6,67331
,,9555e-6,73035
,,20129e-6,76967
tbte,200,2
tbpt,,1896e-6,54978
,,3770e-6,61720
,,9555e-6,66882
,,20129e-6,70582
tbte,300,3
tbpt,,1896e-6,53304
,,3770e-6,59850
,,9555e-6,64831
,,20129e-6,68453
tbte,400,4
tbpt,,1780e-6,51630
,,3770e-6,57979
,,9555e-6,62780
,,20129e-6,66325

![4]                    insulating concrete
insul_alpx=insul_alpx*1e-6                   !in/in/F
insul_dens=insul_gamma/1728                  !lb/in^3

mp,ex,mat_insul,insul_ex
mp,dens,mat_insul,insul_dens
mp,prxy,mat_insul,insul_prxy
mp,alpx,mat_insul,insul_alpx
!tb,concr,mat_insul
!tbda,1,insul_open,insul_closed,insul_crack,-1


![5]                    soil
! These soil properties for material 5 are overwritten later
!soil_ex=575000                     !elastic modulus [psi]
!soil_prxy=0.1                      !Poisson ratio
!soil_alpx=0                        !thermal expansion
coefficient [me/F]
!soil_gamma=125                             !unit weight
[lbf/ft^3]
!soil_cohesion=0                    !drucker-prager constant
(assume small number) [psi]
!soil_friction=35.4                 !internal friction angle
[deg]
!soil_dilat=35.4            !dilatancy angle [deg]

!soil_alpx=soil_alpx*1e-6           !in/in/F
!soil_dens=soil_gamma/1728          !lb2/in^3

!mp,ex,mat_soil,soil_ex
!mp,dens,mat_soil,soil_dens
!mp,prxy,mat_soil,soil_prxy
!mp,alpx,mat_soil,soil_alpx
!tb,dp,mat_soil
!tbdata,1,soil_cohesion,soil_friction,soil_dilat
```

```
!set mat_haunch materials equal to mat_conc material
vsel,s,mat,,mat_haunch
eslv
emodif,all,mat,mat_conc
mpdele,all,mat_haunch

!set slab rebar material properties
vsel,s,mat,,mat_rebar
eslv
nsle
nsel,r,loc,y,-999,-8.125
esln,,1
esel,r,mat,,mat_rebar
mat_srebar=6
emodif,all,mat,mat_srebar

![6]                    slab rebar
srebar_alpx=srebar_alpx*1e-6               !in/in/F
srebar_dens=srebar_gamma/1728                       !lb/in^3

mp,ex,mat_srebar,srebar_ex
mp,dens,mat_srebar,srebar_dens
mp,prxy,mat_srebar,srebar_prxy
mp,alpx,mat_srebar,srebar_alpx
tb,miso,mat_srebar,4,4
tbte,100,1
tbpt,,1379e-6,40000
,,2513e-6,44887
,,6370e-6,48690
,,13419e-6,51311
tbte,200,2
tbpt,,1264e-6,36652
,,2513e-6,41147
,,6370e-6,44588
,,13419e-6,47055
tbte,300,3
tbpt,,1225e-6,35536
,,2513e-6,39900
,,6370e-6,43221
,,13419e-6,45636
tbte,400,4
tbpt,,1187e-6,34420
,,2513e-6,38653
,,6370e-6,41853
,,13419e-6,44217

allsel
esel,s,mat,,3
esel,a,mat,,6
emodif,all,mat,2
allsel
```

Input file: set_options.mac

```
!*** Turn on creep, turn on steel plasticity 6/8/04

/prep7

!remove structural concrete CONCR material model
!tbdele,concr,mat_conc

!remove concrete CREEP material model
!tbdele,creep,mat_conc

!remove insulating concrete CONCR material model
!tbdele,concr,mat_insul

!remove insulating concrete CREEP material model
tbdele,creep,mat_insul

!remove liner BISO material model
!tbdele,BISO,mat_liner

!remove rebar BISO material model
!tbdele,BISO,mat_rebar
!tbde,biso,mat_srebar

!remove soil DP material model
!tbdele,DP,mat_soil
```

Input file: set_parms.mac

```
!***
!***  Upper bound soil   11/21/05
!***  Best estimate soil properties  3/19/04
!***
!*** Run 2, Load Case 1 - 4
!***   (8.3' soil, 125 lb/ft3)
!***   (0.06" primary tank corrosion)
!*** 4/16/03
!***
!***
!***  JED mods 3/20/03
!***  add clr - concentrated load radius
!***  add backfill properties 3/24
!***  backfill properties f(depth)  4/1

finish
/clear
/fil,pnnla
/prep7
/titl,Baseline, Upper Bound Soil
!
! DST - AY

pi=acos(-1)

clr=10*12               !Concentrated load radius
or=12*41.5            !Outside radius concrete wall
ir=12*40              !Inside radius concrete wall
ir2=12*37.5           !Radius primary tank
icr=37*12+3             !Radius insulating concrete
h1=0
h2=-8.125
h3=381.5              !Height dome tangent  (31'9-1/2")
```

h4=h3+70.875 !Height exterior corner (+ 5'10-7/8" = 37'8-3/8")
h5=h3+15*12 !Height interior center dome
h6=h5+15 !Height exterior center dome

covext=2 !Concrete cover - exterior dome
covint1=4 !Concrete cover - wall
covint2=1.5 !Concrete cover - interior dome

r1=105*12+.25 !Exterior dome radius - center
th1=7+(45+14/60)/60 !Angle at tangent of external radii
r2=74*12+4 !Exterior dome radius - outer
r3=3*12+8.375 !Radius primary tank to dome

! This file sets the values of all parameters that may be changed

! These were originally defined in define_soil_layers.mac:

overburden=8.3*12 !overburden height above dome apex (ft)
subdepth=168*12 !subgrade soil depth (ft)
totalwidth=240*12 !total soil width (radius) from tank centerline to edge (ft)

! These were originally defined in dstay7.mac:

r50=1-.06 !shell thickness (in) (R1 of Figure 11 in RPP-13990)
r51=3/8-.06 !shell thickness (in) (R2,R6,R7,R9 of Figure 11 in RPP-13990)
r52=7/8-.06 !shell thickness (in) (R3 of Figure 11 in RPP-13990)
r53=3/4-.06 !shell thickness (in) (R4 of Figure 11 in RPP-13990)
r54=1/2-.06 !shell thickness (in) (R5,R8 of Figure 11 in RPP-13990)
r55=1/4 !shell thickness (in) (R10 of Figure 11 in RPP-13990)

! This was originally defined in set_esys_3d.mac:

r56=3/8 !shell thickness (in) of secondary liner above 357.5 in

! These were originally defined in set_materials.mac:

![1] steel (for liner, jbolts, studs, anchors, bearing plates)
steel_ex=27.7e6 !elastic modulus [psi]
steel_prxy=0.3 !Poisson ratio
steel_alpx=6.38 !thermal expansion coefficient [microstrain/degree F]
steel_gamma=490 !unit weight [lbf/ft^3]
steel_yield=36000 !yield strength [psi]

```
steel_tan=0.01                  !rebar tangent modulus
[% of elastic modulus]

![2]     structural concrete
conc_ex=3.8e6                   !elastic modulus [psi]
conc_prxy=0.15                  !Poisson ratio
conc_alpx=3.7                   !thermal expansion
coefficient [microstrain/degree F]
conc_gamma=145                          !unit weight
[lbf/ft^3]

conc_open=0.1   !shear transfer coefficient for open crack
conc_closed=0.98                !shear transfer
coefficient for closed crack
conc_crush=3000                         !uniaxial
crushing stress [psi]
conc_crack=0.1*conc_crush       !tensile cracking stress
[psi]

![3]            rebar
rebar_ex=29.0e6                 !elastic modulus [psi]
rebar_prxy=0.3                  !Poisson ratio
rebar_alpx=6.                   !thermal expansion
coefficient [microstrain/degree F]
rebar_gamma=490                         !unit weight
[lbf/ft^3]
rebar_yield=71000               !yield strength [psi]
rebar_tan=0                     !rebar tangent modulus
[psi]

![4]     insulating concrete
insul_ex=165e3                  !elastic modulus [psi]
insul_prxy=0.15                 !Poisson ratio
insul_alpx=3.7                  !thermal expansion
coefficient [me/F]
insul_gamma=50                          !unit weight
[lbf/ft^3]

insul_open=0.1                  !shear transfer
coefficient for open crack
insul_closed=0.98               !shear transfer
coefficient for closed crack
insul_crush=200                 !uniaxial crushing stress
[psi]
insul_crack=20                  !tensile cracking stress
[psi]

![6]            slab rebar
srebar_ex=29.0e6                !elastic modulus [psi]
srebar_prxy=0.3                 !Poisson ratio
srebar_alpx=6.                  !thermal expansion
coefficient [microstrain/degree F]
srebar_gamma=490                !unit weight [lbf/ft^3]
srebar_yield=49000              !yield strength [psi]
srebar_tan=0                    !rebar tangent modulus
[psi]


!*** Backfill
! These were originally defined in define_loads.mac:
! [5]          backfill soil
backfill_phi=34.5               !soil friction angle deg
```

```
backfill_dil=34.5                !backfill dilatancy angle
deg
backfill_cte=0                   !thermal expansion coef
me/f

!*** No waste, pressures or ext. load
pres_surf=0                            !ground surface
uniform pressure psf
point_cent=0                           !point load at
center lb
pres_annulus=0                         !annulus
pressure inches h2o
pres_int=0                             !annulus internal
pressure inches h2o
hwaste=35.17*12                        !total waste
height
height_waste1=hwaste/3                 !height of waste
1 inches
gamma_waste1=0                         !specific gravity
of waste 1
height_waste2=hwaste/3                 !height of waste
2 inches
gamma_waste2=0                         !specific gravity
of waste 2
height_waste3=hwaste/3                 !height of waste
3 inches
gamma_waste3=0                         !specific gravity
of waste 3


!define soil layers
```

```
*dim,soil_emod,,16
*dim,soil_pr,,16
*dim,soil_z0,,16
*dim,soil_z1,,16
*dim,bf_emod,,8
!*dim,bf_pr,,8
*dim,bf_z0,,8
*dim,bf_z1,,8
bfdinc=(h6+overburden+18.5)/8
sdinc=(subdepth+60)/8

*do,i,1,8
soil_z0(i)=i*bfdinc        !vertical distance from surface
soil_z1(i)=(i-1)*bfdinc
soil_z0(i+8)=i*sdinc+bfdinc*8
soil_z1(i+8)=(i-1)*sdinc+bfdinc*8
bf_z0(i)=i*bfdinc
bf_z1(i)=(i-1)*bfdinc
*enddo

!Elastic modulus
soil_emod(1)=75000,78000,80524,83049,85292,87817,
90341,92585,97398,105000
soil_emod(11)=140494,176448,215742,254268,287000,
315000
bf_emod(1)=16000,20000,26136,32273,37727,43864,
50000,54000

!Poisson's ratio
soil_pr(1)=.24,.24,.24,.24,.19,.19,.19,.19,.19,.19
soil_pr(11)=.19,.19,.28,.28,.28,.28
```

```
bf_pr=.27

!*** Soil 110 pcf - undisturbed
!*** Soil 125 pcf - backfill/overburden
s_gam=110            !lbf/ft^3 density of soil layers
(excluding backfill)
b_gam=125            !lbf/ft^3 density of soil layers
(excluding backfill)

save
```

Input file: set_real.mac

```
*get,ia,area,,num,min
*get,iamat,area,ia,attr,mat
*get,iatype,area,ia,attr,type
*get,iacsys,area,ia,attr,esys
aatt,iamat,arg1,iatype,iacsys
```

Input file: set_rx.mac

```
cmsel,s,arg4
csys,0
asel,r,loc,x,arg1,arg2
set_real,arg3
```

Input file: set_ry.mac

```
cmsel,s,arg4
csys,0
asel,r,loc,y,arg1,arg2
set_real,arg3
```

Input file: set_slayer.mac

```
!***
!***Dilation angle 8   6/4/04
!***Add materials for load factor restart 8/2/03
!***  JED mod 3/24/03
!***    Define soil
!***     (redefine backfill/overburden in set_backfill)
!***
max_mat=max_mat+1

/prep7

cmsel,s,soil_elem
nsle

csys,0
hsub=top_elev-arg2-h2+24
nsel,r,loc,y,top_elev-arg1,top_elev-arg2
esln,
esel,r,mat,,5
emodif,all,mat,max_mat
emodif,all,real,7


soil_ex=arg3                  !elastic modulus [psi]
soil_prxy=arg4                !Poisson ratio
soil_alpx=0                   !thermal expansion
coefficient [me/F]
soil_cohesion=1               !drucker-prager constant
[psi]
soil_friction=35          !internal friction angle [deg]
soil_dilat=8                  !dilatancy angle [deg]
```

```
soil_alpx=soil_alpx*1e-6          !in/in/F
soil_dens=s_gam/1728              !lb/in^3

mp,ex,max_mat,soil_ex
mp,dens,max_mat,soil_dens
mp,prxy,max_mat,soil_prxy
mp,alpx,max_mat,soil_alpx
tb,dp,max_mat
tbdata,1,soil_cohesion,soil_friction,soil_dilat

!*** materials max_mat+50 for load factor restart

mp,ex,max_mat+50,soil_ex
mp,dens,max_mat+50,soil_dens*1.7/1.4
mp,prxy,max_mat+50,soil_prxy
mp,alpx,max_mat+50,soil_alpx
tb,dp,max_mat+50
tbdata,1,soil_cohesion,soil_friction,soil_dilat
```

Input file: set_soil.mac

```
!***
!***  JED mod 3/24/03
!***    define subdepth (depth of soil below foundation
!***
/prep7

csys,0
vsel,s,mat,,1
aslv
asel,u,loc,z,0
cm,aold,area
aslv
asel,r,loc,z,0
cm,anew,area
eslv
nsle
cpdele,all,all
vclear,all
vdele,all
cmsel,s,aold
adele,all,,,1
cmsel,s,anew
lsla
lesize,all,,,-1,,1
esize,16

adrag,1986,,,,,,1989
aovlap,all
cm,asoil,area
asel,s,,,147
adele,all,,,1
cmsel,s,asoil
lcomb,14,1983
aatt,mat_soil,,type_soil
amesh,all

allsel
*get,km,kp,,num,max
dy=overburden-12

k,km+1,kx(1112)-dy,ky(1110)+dy
```

```
k,km+2,kx(1075)-dy,ky(1075)-dy
k,km+3,0,ky(km+2)
k,km+4,kx(km+2),ky(1077)-subdepth
k,km+5,0,ky(km+4)
k,km+6,0,ky(km+1)
k,km+7,-totalwidth,ky(km+1)
k,km+8,kx(km+7),ky(km+2)
k,km+9,kx(km+8),ky(km+4)
k,km+10,-clr,ky(km+1)
asel,none
a,1112,1110,km+6,km+10,km+1
a,km+1,km+2,1075,1112
a,km+2,km+3,1077,1075
a,km+2,km+4,km+5,km+3
a,km+1,km+7,km+8,km+2
a,km+2,km+8,km+9,km+4
lsla
lsel,r,loc,x,kx(km+7)+1,kx(km+1)-1
lesize,all,,,40,1/10
lsel,r,loc,y,ky(km+1)
lesize,all,,,40,10,1
lsla
lsel,r,loc,y,ky(km+9)+1,ky(km+8)-1
lesize,all,,,40,10
lsel,r,loc,x,0
lesize,all,,,40,.1,1
lsla
aatt,mat_soil,,type_soil
amap,147,1112,1110,3261,3256
asel,u,,,147
mshkey,1
amesh,all

asel,s,mat,,mat_soil
type,type_soil+10
mat,mat_soil
ksel,all
vsel,none
vrotat,all,,,,,,ikbot,iktop,swp_th,1
aclear,all

csys,22
nrotate,all

!couple to concrete DOFs
asel,,,,462,466,4
,a,,,473
,a,,,469,471
,a,,,482,483
,a,,,488,491,3
cm,avert,area
asel,,,,472,481,9
,a,,,478,479
cm,ahorz,area

esel,s,mat,,2
nsle
nsel,r,ext
cm,nconc,node

cmsel,s,avert
nsla,,1
```

```
cm,nsoil,node
*get,nnode,node,,count
*do,i,1,nnode
 *get,inode,node,,num,min
 cmsel,s,nconc
 incoup=node(nx(inode),ny(inode),nz(inode))
 nsel,s,,,incoup
 nsel,a,,,inode
 cp,next,uz,all
 cmsel,s,nsoil
 nsel,u,,,inode
 cm,nsoil,node
*enddo

cmsel,s,ahorz
nsla,,1
cm,nsoil,node
*get,nnode,node,,count
*do,i,1,nnode
 *get,inode,node,,num,min
 cmsel,s,nconc
 incoup=node(nx(inode),ny(inode),nz(inode))
 nsel,s,,,incoup
 nsel,a,,,inode
 cp,next,ux,all
 cmsel,s,nsoil
 nsel,u,,,inode
 cm,nsoil,node
*enddo

/eof
```

```
csys,22
nsel,s,loc,y,180-.01,180+.01
nsel,a,loc,y,180+swp_th-.01,180+swp_th+.01
nrotate,all
d,all,uy,0
allsel
```

Input file: set_type.mac

```
*get,ia,area,,num,min
*get,iareal,area,ia,attr,real
*get,iamat,area,ia,attr,mat
*get,iacsys,area,ia,attr,esys
aatt,iamat,iareal,arg1,iacsys
```

E.2.2 Thermal Cycling Files

Input file: set_sliceb.inp

```
!***
!***Use nsub     6/24/04
!***Adjust mpch (new SS temps) & Day 48 Steady-State
6/8/04
!***Adjust substeps 6/7/04
!***2 year thermal cycle  ****inp modified****5/19/04
!***    multiple heating and cooling load steps
!***

/fil,set_slice_0
resu

/sol
```

```
anty,,rest

!*** Thermal load - Initial ramp
!***
fhrt=7.5/24

time,3+fhrt                  !LS 4
!***
!***  Fast heat to 125F
!***
/nopr
/inp,frh,temp
/inp,bkh,temp
/gopr
nsub,3,10,2
solv


time,6+fhrt                  !LS 5
!***
!***  First of four steps to 350F
!***
/nopr
/inp,frh1,temp
/inp,bkh1,temp
/gopr
nsub,20,100,6
solv

time,9+fhrt                  !LS 6
!***
!***  Second of four steps to 350F
!***
/nopr
/inp,frh2,temp
/inp,bkh2,temp
/gopr
nsub,20,100,6
solv

time,12+fhrt                 !LS 7
!***
!***  Third of four steps to 350F
!***
/nopr
/inp,frh3,temp
/inp,bkh3,temp
/gopr
nsub,20,100,6
solv

time,14.25+fhrt              !LS 8
!***
!***  Four of four steps to 350F
!***
/nopr
/inp,frh4,temp
/inp,bkh4,temp
/gopr
nsub,20,100,6
solv
```

```
time,33                      !LS 9
!***  350F
/nopr
/inp,frss,temp
/inp,bkss,temp
/gopr
nsub,150,1000,10
solv

time,48                      !LS 10
!***  Steady-state @ 350F
/nopr
/inp,frss1,temp
/inp,bkss1,temp
/gopr
nsub,150,1000,15
solv


time,353              !LS 11
!***  Hold for 1 Year
nsub,300,10000,10
solv

time,353+1                   !LS 12
!***  mpchg and 1.0 days
*do,i,1,14
esel,,type,,12,15
nsle
nsel,r,bf,temp,190+i*10,200+i*10
esln
esel,r,mat,,2
mpch,20+i,all
*enddo
esel,,type,,12,15
nsle
nsel,r,bf,temp,330,345
esln
esel,r,mat,,2
mpch,35,all
esel,all
nsel,all
nsub,10,100,2
solv


time,357              !LS 13
!***  Cool to ambient
!***
!***  First of four steps to 125F
!***
/nopr
/inp,frc1,temp
/inp,bkc1,temp
/gopr
nsub,15,200,5
solv

time,360              !LS 14
!***
!***  Second of four steps to 125F
!***
```

```
/nopr
/inp,frc2,temp
/inp,bkc2,temp
/gopr
nsub,15,200,5
solv

time,363            !LS 15
!***
!***  Third of four steps to 125F
!***
/nopr
/inp,frc3,temp
/inp,bkc3,temp
/gopr
nsub,15,200,5
solv

time,365.25                 !LS 16
!***
!***  Four of four steps to 125F
!***
/nopr
/inp,frc4,temp
/inp,bkc4,temp
/gopr
nsub,15,200,5
solv

time,365.5625              !LS 17
!***
!***  Fast cool down to 50F
!***
/nopr
/inp,frc5,temp
/inp,bkc5,temp
/gopr
nsub,7,100,3
solv


time,366.5625               !LS 18
!***
!***  Tank cool down transient to 50F
!***
/nopr
/inp,frc6,temp
/inp,bkc6,temp
/gopr
nsub,5,100,2
solv


time,368            !LS 19
!****  Uniform 50F
nsub,47,150,20
bf,all,temp,50
solv



!***  Cycle once
```

```
time,368+fhrt              !LS 20
!***
!***  Thermal load - Initial ramp
!***
/nopr
/inp,frh,temp
/inp,bkh,temp
/gopr
nsub,3,10,2
solv


time,368+3+fhrt !LS 21
!***
!***  First of four steps to 350F
!***
/nopr
/inp,frh1,temp
/inp,bkh1,temp
/gopr
nsub,20,100,6
solv

time,368+6+fhrt !LS 22
!***
!***  Second of four steps to 350F
/nopr
/inp,frh2,temp
/inp,bkh2,temp
/gopr
nsub,20,100,6
solv

time,368+9+fhrt            !LS 23
!***
!***  Third of four steps to 350F
!***
/nopr
/inp,frh3,temp
/inp,bkh3,temp
/gopr
nsub,20,100,6
solv

time,368+11.25+fhrt        !LS 24
!***
!***  Four of four steps to 350F
!***
/nopr
/inp,frh4,temp
/inp,bkh4,temp
/gopr
nsub,20,100,6
solv


time,368+30                !LS 25
!***
!***  350F
!***
```

E.59

```
/nopr
/inp,frss,temp
/inp,bkss,temp
/gopr
nsub,150,1000,10
solv

time,368+45                 !LS 26
!***
!***  Steady-state @ 350F
!***
/nopr
/inp,frss1,temp
/inp,bkss1,temp
/gopr
nsub,150,1000,30
solv

time,368+351                !LS 27
!***
!***  Creep for 1 Year
!***
nsub,300,10000,6
solv


!***  Cool to ambient


time,368+354                !LS 28
!***
!***  First of four steps to 125F
!***
/nopr
/inp,frc1,temp
/inp,bkc1,temp
/gopr
nsub,15,200,5
solv


time,368+357                !LS 29
!***
!***  Second of four steps to 125F
!***
/nopr
/inp,frc2,temp
/inp,bkc2,temp
/gopr
nsub,15,200,5
solv


time,368+360                !LS 30
!***
!***  Third of four steps to 125F
!***
/nopr
/inp,frc3,temp
/inp,bkc3,temp
/gopr
nsub,15,200,5
```

```
solv


time,368+362.25                    !LS 31
!***
!*** Four of four steps to 125F
!***
/nopr
/inp,frc4,temp
/inp,bkc4,temp
/gopr
nsub,15,200,5
solv


time,368+362.5625          !LS 32
!***
!*** Fast cool down to 50F
!***
/nopr
/inp,frc5,temp
/inp,bkc5,temp
/gopr
nsub,7,100,3
solv


time,368+363.5625          !LS 33
!***
!*** Tank cool down transient to 50F
!***
/nopr
/inp,frc6,temp
/inp,bkc6,temp
/gopr
nsub,5,100,2
solv


time,368+365               !LS 34
!***
!**** Uniform 50F
!***
nsub,47,150,20
bf,all,temp,50
save
solv
```

Input file: set_slicec.inp

```
!***
!***   Years 3 - 5  6/28/04
!***   Adjust mpch (new SS temps) & Day 48 Steady State
6/8/04
!***   Adjust substeps 6/7/04
!***   2 year thermal cycle  ****inp modified****5/19/04
!***   multiple heating and cooling load steps
!***

/fil,set_slice_0
resu
/sol
```

E.61

```
anty,,rest

!*** Thermal load - Initial ramp
!***
fhrt=7.5/24

*do,i,2,4

time,3+fhrt+365*i              !LS 35, 50, 65
!***
!***  Fast heat to 125F
!***
/nopr
/inp,frh,temp
/inp,bkh,temp
/gopr
nsub,3,10,2
solv


time,6+fhrt+365*i              !LS 36, 51, 66
!***
!***  First of four steps to 350F
!***
/nopr
/inp,frh1,temp
/inp,bkh1,temp
/gopr
nsub,20,100,6
solv

time,9+fhrt+365*i              !LS 37, 52, 67
!***
!***  Second of four steps to 350F
!***
/nopr
/inp,frh2,temp
/inp,bkh2,temp
/gopr
nsub,20,100,6
solv

time,12+fhrt+365*i             !LS 38, 53, 68
!***
!***  Third of four steps to 350F
!***
/nopr
/inp,frh3,temp
/inp,bkh3,temp
/gopr
nsub,20,100,6
solv

time,14.25+fhrt+365*i                  !LS 39, 54, 69
!***
!***  Four of four steps to 350F
!***
/nopr
/inp,frh4,temp
/inp,bkh4,temp
/gopr
nsub,22,200,10
```

```
solv

time,33+365*i                    !LS 40, 55, 70
!***  350F
/nopr
/inp,frss,temp
/inp,bkss,temp
/gopr
nsub,180,2000,40
solv

time,48+365*i                    !LS 41, 56, 71
!***  Steady state @ 350F
/nopr
/inp,frss1,temp
/inp,bkss1,temp
/gopr
nsub,150,1000,25
solv

!***  Hold for 1 Year

time,354+365*i                   !LS 42, 57, 72
nsub,300,10000,6
solv

!***  Cool to ambient

time,357+365*i                   !Ls 43, 58, 73
!***
!***  First of four steps to 125F
!***
/nopr
/inp,frc1,temp
/inp,bkc1,temp
/gopr
nsub,15,200,5
solv

time,360+365*i                   !LS 44, 59, 74
!***
!***  Second of four steps to 125F
!***
/nopr
/inp,frc2,temp
/inp,bkc2,temp
/gopr
nsub,15,200,5
solv

time,363+365*i                   !LS 45, 60, 75
!***
!***  Third of four steps to 125F
!***
/nopr
/inp,frc3,temp
/inp,bkc3,temp
/gopr
nsub,15,200,5
solv

time,365.25+365*i                !LS 46, 61, 76
```

```
!***
!***  Four of four steps to 125F
!***
/nopr
/inp,frc4,temp
/inp,bkc4,temp
/gopr
nsub,15,200,5
solv

time,365.5625+365*i                 !LS 47, 62, 77
!***
!***  Fast cool down to 50F
!***
/nopr
/inp,frc5,temp
/inp,bkc5,temp
/gopr
nsub,7,100,3
solv


time,366.5625+365*i                 !LS 48, 63, 78
!***
!***  Tank cool down transient to 50F
!***
/nopr
/inp,frc6,temp
/inp,bkc6,temp
/gopr
nsub,5,100,2
solv


time,368+365*i                      !LS 49, 64, 79
!****  Uniform 50F
nsub,47,150,20
bf,all,temp,50
solv

*enddo
```

Input file: set_slicef.inp

```
!***
!***     Creep 55 years       7/2/04
!***     Use nsub    6/24/04
!***     Adjust mpch (new SS temps) & Day 48 Steady State
6/8/04
!***     Adjust substeps 6/7/04
!***     2 year thermal cycle  ****inp modified****5/19/04
!***    multiple heating and cooling load steps
!***

/fil,set_slice_0
resu

/sol
anty,,rest

!*** Thermal load - Initial ramp
!***
```

```
fhrt=7.5/24

time,1828+fhrt                  !LS 80
!***
!***  Fast heat to 125F
!***
/nopr
/inp,frh,temp
/inp,bkh,temp
/gopr
nsub,3,10,2
solv


time,1831+fhrt                  !LS 81
!***
!***  First of four steps to 350F
!***
/nopr
/inp,frh1,temp
/inp,bkh1,temp
/gopr
nsub,20,100,6
solv

time,1834+fhrt                  !LS 82
!***
!***  Second of four steps to 350F
!***
/nopr
/inp,frh2,temp
/inp,bkh2,temp
/gopr
nsub,20,100,6
solv

time,1837+fhrt                  !LS 83
!***
!***  Third of four steps to 350F
!***
/nopr
/inp,frh3,temp
/inp,bkh3,temp
/gopr
nsub,20,100,6
solv

time,1839.25+fhrt               !LS 84
!***
!***  Four of four steps to 350F
!***
/nopr
/inp,frh4,temp
/inp,bkh4,temp
/gopr
nsub,22,200,10
solv

time,1858                       !LS 85
!***  350F
/nopr
/inp,frss,temp
```

```
/inp,bkss,temp
/gopr
nsub,180,2000,30
solv

time,1873                    !LS 86
!*** Steady state @ 350F
/nopr
/inp,frss1,temp
/inp,bkss1,temp
/gopr
nsub,150,1000,15
solv


time,354+365*59                    !LS 87
!*** Hold for 55 Years
nsub,20000,100000,40
solv


!*** Cool to ambient


time,357+365*59                    !LS 88
!***
!*** First of four steps to 125F
!***
/nopr
/inp,frc1,temp
/inp,bkc1,temp
/gopr
nsub,15,200,5
solv

time,360+365*59                    !LS 89
!***
!*** Second of four steps to 125F
!***
/nopr
/inp,frc2,temp
/inp,bkc2,temp
/gopr
nsub,15,200,5
solv


time,363+365*59                    !LS 90
!***
!*** Third of four steps to 125F
!***
/nopr
/inp,frc3,temp
/inp,bkc3,temp
/gopr
nsub,15,200,5
solv


time,365.25+365*59                 !LS 91
!***
```

```
!***  Four of four steps to 125F
!***
/nopr
/inp,frc4,temp
/inp,bkc4,temp
/gopr
nsub,15,200,5
solv


time,365.5625+365*59            !LS 92
!***
!***  Fast cool down to 50F
!***
/nopr
/inp,frc5,temp
/inp,bkc5,temp
/gopr
nsub,7,100,3
solv


time,366.5625+365*59            !LS 93
!***
!***  Tank cool down transient to 50F
!***
/nopr
/inp,frc6,temp
/inp,bkc6,temp
/gopr
nsub,5,100,2
solv


time,365*60+3                   !LS 94
!***
!****  Uniform 50F
!***
nsub,47,150,20
bf,all,temp,50
save
solv
```

Input file: set_sliceg.inp

```
!***
!***    Year 61      8/23/04
!***    Adjust mpch (new SS temps) & Day 48 Steady State
6/8/04
!***    Adjust substeps 6/7/04
!***    2 year thermal cycle  ****inp modified****5/19/04
!***   multiple heating and cooling load steps
!***

/fil,set_slice_0
resu
/sol
anty,,rest

!*** Thermal load - Initial ramp
!***
fhrt=7.5/24
```

```
time,3+fhrt+365*60
!***
!***  Fast heat to 125F
!***
/nopr
/inp,frh,temp
/inp,bkh,temp
/gopr
nsub,3,10,2
solv


time,6+fhrt+365*60
!***
!***  First of four steps to 350F
!***
/nopr
/inp,frh1,temp
/inp,bkh1,temp
/gopr
nsub,20,100,6
solv

time,9+fhrt+365*60
!***
!***  Second of four steps to 350F
!***
/nopr
/inp,frh2,temp
/inp,bkh2,temp
/gopr
nsub,20,100,6
solv

time,12+fhrt+365*60
!***
!***  Third of four steps to 350F
!***
/nopr
/inp,frh3,temp
/inp,bkh3,temp
/gopr
nsub,20,100,6
solv

time,14.25+fhrt+365*60
!***
!***  Four of four steps to 350F
!***
/nopr
/inp,frh4,temp
/inp,bkh4,temp
/gopr
nsub,22,200,10
solv

time,33+365*60
!***  350F
/nopr
/inp,frss,temp
/inp,bkss,temp
```

```
/gopr
nsub,180,2000,40
solv

time,48+365*60
!*** Steady state @ 350F
/nopr
/inp,frss1,temp
/inp,bkss1,temp
/gopr
nsub,150,1000,25
solv

!*** Hold for 1 Year

time,354+365*60
nsub,300,10000,6
solv

!*** Cool to ambient

time,357+365*60
!***
!*** First of four steps to 125F
!***
/nopr
/inp,frc1,temp
/inp,bkc1,temp
/gopr
nsub,15,200,5
solv

time,360+365*60
!***
!*** Second of four steps to 125F
!***
/nopr
/inp,frc2,temp
/inp,bkc2,temp
/gopr
nsub,15,200,5
solv

time,363+365*60
!***
!*** Third of four steps to 125F
!***
/nopr
/inp,frc3,temp
/inp,bkc3,temp
/gopr
nsub,15,200,5
solv

time,365.25+365*60
!***
!*** Four of four steps to 125F
!***
/nopr
/inp,frc4,temp
/inp,bkc4,temp
/gopr
```

```
nsub,15,200,5
solv

time,365.5625+365*60
!***
!***  Fast cool down to 50F
!***
/nopr
/inp,frc5,temp
/inp,bkc5,temp
/gopr
nsub,7,100,3
solv


time,366.5625+365*60
!***
!***  Tank cool down transient to 50F
!***
/nopr
/inp,frc6,temp
/inp,bkc6,temp
/gopr
nsub,5,100,2
solv


time,368+365*60
!****  Uniform 50F
nsub,47,150,20
bf,all,temp,50
save
solv
```

E.2.3 ACI Load Factors

Input file: set_sliced.inp

```
!***
!***    Load factors  8/22/03
!***    1.4 g
!***    1.4 pressures
!***    1.4 waste
!***    1.7/1.4 soil density
!***    1.7 distributed & concentrated load
!***

/fil,set_slice_0
resu

/sol
anty,,rest

!***
!***

time,365*61+4
nsub,10,100,5

acel,,1.4
```

```
pres_surf=40*1.7                !ground surface uniform
pressure psf
point_cent=200000*1.7                !point load at
center lb
pres_annulus=-20*1.4                !annulus
pressure inches h2o
pres_int=-12*1.4                !annulus internal
pressure inches h2o
hwaste=35.17*12                !total waste
height
height_waste1=hwaste/3                !height of waste
1 inches
gamma_waste1=1.7*1.4                !specific gravity
of waste 1
height_waste2=hwaste/3                !height of waste
2 inches
gamma_waste2=1.7*1.4                !specific gravity
of waste 2
height_waste3=hwaste/3                !height of waste
3 inches
gamma_waste3=1.7*1.4                !specific gravity
of waste 3

/inp,apply_loads_slice,mac

!***
!***     mpch to change density of soils
!***
*do,i,1,16
esel,,mat,,100+i
mpch,150+i,all
*enddo
*do,i,1,8
esel,,mat,,120+i
mpch,170+i,all
*enddo
esel,all

save
solv
```

Input file: set_sliceh.inp

```
!***
!***     Year 61      9/7/04   1.4D+1.7L+1.05T
!***     Adjust mpch (new SS temps) & Day 48 Steady State
6/8/04
!***     Adjust substeps 6/7/04
!***     2 year thermal cycle  ****inp modified****5/19/04
!***    multiple heating and cooling load steps
!***

/fil,set_slice_0
resu
/sol
anty,,rest

!*** Thermal load - Initial ramp
!***
fhrt=7.5/24
```

E.71

```
time,3+fhrt+365*61+1
!***
!***  Fast heat to 125F
!***
/nopr
/inp,frh,temp
/inp,bkh,temp
/gopr
bfsc,temp,1.05,50
nsub,3,10,2
solv


time,6+fhrt+365*61+1
!***
!***  First of four steps to 350F
!***
/nopr
/inp,frh1,temp
/inp,bkh1,temp
/gopr
bfsc,temp,1.05,50
nsub,20,100,6
solv

time,9+fhrt+365*61+1
!***
!***  Second of four steps to 350F
!***
/nopr
/inp,frh2,temp
/inp,bkh2,temp
/gopr
bfsc,temp,1.05,50
nsub,20,100,6
solv

time,12+fhrt+365*61+1
!***
!***  Third of four steps to 350F
!***
/nopr
/inp,frh3,temp
/inp,bkh3,temp
/gopr
bfsc,temp,1.05,50
nsub,20,100,6
solv

time,14.25+fhrt+365*61+1
!***
!***  Four of four steps to 350F
!***
/nopr
/inp,frh4,temp
/inp,bkh4,temp
/gopr
bfsc,temp,1.05,50
nsub,22,200,10
solv

time,33+365*61+1
```

E.72

```
!***  350F
/nopr
/inp,frss,temp
/inp,bkss,temp
/gopr
bfsc,temp,1.05,50
nsub,180,2000,40
solv

time,48+365*61+1
!***  Steady state @ 350F
/nopr
/inp,frss1,temp
/inp,bkss1,temp
/gopr
bfsc,temp,1.05,50
nsub,150,1000,25
solv

!***  Hold for 1 Year

time,354+365*61+1
nsub,300,10000,6
solv

!***  Cool to ambient

time,357+365*61+1
!***
!***  First of four steps to 125F
!***
/nopr
/inp,frc1,temp
/inp,bkc1,temp
/gopr
bfsc,temp,1.05,50
nsub,15,200,5
solv

time,360+365*61+1
!***
!***  Second of four steps to 125F
!***
/nopr
/inp,frc2,temp
/inp,bkc2,temp
/gopr
bfsc,temp,1.05,50
nsub,15,200,5
solv

time,363+365*61+1
!***
!***  Third of four steps to 125F
!***
/nopr
/inp,frc3,temp
/inp,bkc3,temp
/gopr
bfsc,temp,1.05,50
nsub,15,200,5
solv
```

```
time,365.25+365*61+1
!***
!*** Four of four steps to 125F
!***
/nopr
/inp,frc4,temp
/inp,bkc4,temp
/gopr
bfsc,temp,1.05,50
nsub,15,200,5
solv

time,365.5625+365*61+1
!***
!*** Fast cool down to 50F
!***
/nopr
/inp,frc5,temp
/inp,bkc5,temp
/gopr
bfsc,temp,1.05,50
nsub,7,100,3
solv


time,366.5625+365*61+1
!***
!*** Tank cool down transient to 50F
!***
/nopr
/inp,frc6,temp
/inp,bkc6,temp
/gopr
bfsc,temp,1.05,50
nsub,5,100,2
solv


time,368+365*61+1
!**** Uniform 50F
nsub,47,150,20
bf,all,temp,50
save
solv
```

E.3 Postprocessing files

There are four postprocessing files associated with the ACI evaluation, the ASME evaluation of the primary and secondary liner, and the J-bolts. They are listed below.

Input file: paci11.inp

```
!***
!*** ACI postprocessing
!***     9/2/04  Automate for year 61
!***     8/3/04  Delete section 64
!***     1/15/04 Revised
!***     9/8/03 Add 6 locations to foundation
!***     9/4/03 Use pcal,intg for hoop direction
!*******************************
!***     9/3/03 Add titles - change as necessary!!
```

```
!*******************************
!***     8/23/03 (FSUM)
!***

*dim,dox,,15
dox(1)=30,61,90,120,152,183,210,237.5,270,304.5
dox(11)=314,334,354,368.9,390.2
*dim,thx,,9
thx(1)=146.6,148.9,152.0,154.91,158.75,163.9,168.1,172.35,
176.177
*dim,wh,,23
wh(1)=382.1,361.5,346.1,335,321,306,300,281,260.5,236
wh(11)=212.7,200,186.8,171,151.6,145.5,120.5,100.5,80,60
wh(21)=39.9,21,-4.5
*dim,dsx,,16
dsx(1)=514,503,489,477,461.5,440,421.4,390,358,338
dsx(11)=277.7,218.5,180,129.9,95.7,54

*do,m,95,109
set,m

*cfo,ls%m%,aci
*afun,deg
!*** Titles
tt1='Baseline'
tt2='Year 61'
tt3='ls%m%'
tt4a='40 psf uniform,'
tt4b='100 ton concentrated,'
tt4c='-20 in. annulus,'
tt4d='-6 in. vapor space'
!tt4d='None'
!tt5='1.4(D + F) + 1.7(L + H)'
tt5='None'
!*** Column headings
ct1='Section'
ct2='  shear'
ct3='F-merid '
ct4='M-merid '
ct5='F-hoop  '
ct6='M-hoop  '
ct7='Tmin    '
ct8='Tmax    '
ct9='Tave    '
ct10='xbar    '
ct11='ybar    '
ct12='sect thk'
ttb='    '

*vwri,tt1
%c
*vwri,tt2
%c
*vwri,tt3
%c
*vwri,tt4a,tt4b,tt4c,tt4d
%c %c %c %c
*vwri,tt5
%c
*vwri,ttb
(a8)
*vwri,ttb
```

```
(a8)
*vwri,ttb
(a8)
*vwri,ct1,ct2,ct3,ct4,ct5,ct6,ct7,ct8,ct9,ct10,ct11,ct12
(12a8)
*vwri,ttb
(a8)

!***
!*** Dome

k=0
csys
esel,,type,,12,15
nsle

!***     Find center of outer arc
cdl=distkp(6,18)
cda=asin(cdl/(2*r2))
cthet=atan((ky(6)-ky(18))/(kx(6)-kx(18)))
cgam=90-cda-cthet
cdelx=r2*cos(cgam)
cdely=r2*sin(cgam)
orcirx=kx(18)+cdelx
orciry=ky(18)-cdely

*do,i,1,15
k=k+1
esel,,type,,12,15
nsle
csys
x1=dox(i)
thed1=acos(x1/480)
y1=h5-180+180*sin(thed1)
*if,i,le,5,then
thd1=asin(x1/(r1-15))
x2=r1*sin(thd1)
y2=h6-r1+r1*cos(thd1)
*else
thd1=atan((y1-orciry)/(x1+orcirx))
x2=r2*cos(thd1)-orcirx
y2=r2*sin(thd1)+orciry
thd1=90-thd1
*endif

path,sect %k%,2,,200
ppat,1,,-x1,y1
,2,,-x2,y2

nsel,r,loc,y,400,599
loca,45,,-x1,y1,,thd1-90
nsel,r,loc,y,-3,500
esln,,1
esel,r,type,,12,15
*if,i,eq,8,then
esel,a,,,8995
*elseif,i,eq,9,then
esel,a,,,9181
*elseif,i,eq,11,then
esel,a,,,9200
*elseif,i,eq,12,then
esel,a,,,8941
```

```
*elseif,i,eq,13,then
esel,a,,,8825
*elseif,i,eq,14,then
esel,a,,,8999
*endif
cm,upper,elem

pdef,temp,bfe,temp
pcalc,intg,itemp,temp,s
*get,delt,path,,last,s

nsel,r,loc,y,-3,0
,r,loc,z
*if,i,eq,10,then
nsel,u,,,2990
*endif
*get,ncount,node,,count
cm,sectn,node
slocxt=0
slocyt=0
secx=0
secy=0
csys
rsys
*do,j,1,ncount
ncur=ndnext(j)
slocxt=slocxt+nx(ncur)+ux(ncur)
slocyt=slocyt+ny(ncur)+uy(ncur)
secx=secx+nx(ncur)
secy=secy+ny(ncur)
nsel,u,,,ncur
*enddo
rsys,45
slocx=slocxt/ncount
slocy=slocyt/ncount
xbar=-secx/ncount
ybar=secy/ncount

secw=xbar*swp_th/2*pi/180
cmse,,sectn
rsys,45
spoi,,slocx,slocy
fsum,rsys
*get,smeru,fsum,,item,fx
*get,pmeru,fsum,,item,fy
*get,mmeru,fsum,,item,mz
*get,tmin,path,,min,temp
*get,tmax,path,,max,temp
*get,ttot,path,,last,itemp
esel,,type,,12,15
cmse,u,upper
fsum
*get,smerl,fsum,,item,fx
*get,pmerl,fsum,,item,fy
*get,mmerl,fsum,,item,mz
smer=(smeru-smerl)/2
pmer=(pmeru-pmerl)/2
mmer=(mmeru-mmerl)/2

!** Calculate hoop area
esln
esel,r,type,,12,15
```

E.77

```
*if,i,eq,8,then
esel,u,,,8996
*elseif,i,eq,9,then
esel,u,,,9182
*elseif,i,eq,10,then
esel,u,,,9203
*elseif,i,eq,11,then
esel,u,,,9199
*elseif,i,eq,12,then
esel,u,,,8942
*elseif,i,eq,13,then
esel,u,,,8824
*elseif,i,eq,14,then
esel,u,,,8998
*endif
nsle
nsel,r,loc,z
*get,ecount,elem,,count
hparea=0
*do,j,1,ecount
ecur=elnext(j)
hparea=hparea+arface(ecur)
esel,u,,,ecur
*enddo
hparea=hparea/2
hpw=hparea/delt

esel,,type,,12,15
cmse,,sectn
fsum,rsys
*get,php,fsum,,item,fz
*get,mhp,fsum,,item,my

tave=ttot/delt
smer=smer/secw*12/1000
pmer=pmer/secw*12/1000
mmer=-mmer/secw/1000
php=php/hpw*12/1000
mhp=mhp/hpw/1000

*vwri,k,smer,pmer,mmer,php,mhp,tmin,tmax,tave,xbar,ybar,
delt
(11f8.1,f8.2)
*enddo

!*** Haunch

csys
esel,,type,,12,15
nsle

!***     Find center of outer arc
csys
cdl=distkp(6,18)
cda=asin(cdl/(2*r2))
cthet=atan((ky(6)-ky(18))/(kx(6)-kx(18)))
cgam=90-cda-cthet
cdelx=r2*cos(cgam)
cdely=r2*sin(cgam)
orcirx=kx(18)+cdelx
orciry=ky(18)-cdely
```

```
*do,i,1,9
k=k+1
esel,,type,,12,15
nsle
csys
x1=480*cos(thx(i))
y1=480*sin(thx(i))*.375+h3
*if,i,le,4,then
thd1=atan((y1-orciry)/(x1-orcirx))
x2=orcirx-r2*cos(thd1)
y2=orciry-r2*sin(thd1)
*elseif,i,eq,5,then
thd1=atan((y1-orciry)/(x1-orcirx))+5
x2=orcirx-r2*cos(thd1-4.85)
y2=orciry-r2*sin(thd1-4.85)
*elseif,i,eq,6,then
thd1=atan((y1-orciry)/(x1-orcirx))+11
x2=orcirx-r2*cos(thd1-10.5)
y2=orciry-r2*sin(thd1-10.5)
*elseif,i,eq,7,then
x2=-498
y2=427.6
thd1=atan((y2-y1)/(x2-x1))
*elseif,i,eq,8,then
x2=-498
y2=408.8
thd1=atan((y2-y1)/(x2-x1))
*else
x2=-498
y2=393.5
*endif
```

```
path,sect %k%,2,,200
ppat,1,,x1,y1
,2,,x2,y2

nsel,r,loc,y,380,599
loca,45,,x1,y1,,thd1
nsel,r,loc,y,-3,500
esln,,1
esel,r,type,,12,15
*if,i,eq,4,then
esel,u,,,8475
*elseif,i,eq,6,then
esel,a,,,9403,9434,31
,a,,,9480,9640,160
*elseif,i,eq,7,then
esel,u,,,9455
*endif
cm,upper,elem

rsys,45
pdef,temp,bfe,temp
pcalc,intg,itemp,temp,s
*get,delt,path,,last,s

nsel,r,loc,y,-3,0
,r,loc,z
*if,i,eq,4,then
nsel,u,,,2692,2694,2
*elseif,i,eq,6,then
nsel,a,,,3807,3820,13
```

```
*elseif,i,eq,7,then
nsel,u,,,3822,3824,2
,u,,,2707
*endif
*get,ncount,node,,count
cm,sectn,node
slocxt=0
slocyt=0
secx=0
secy=0
csys
rsys
*do,j,1,ncount
ncur=ndnext(j)
slocxt=slocxt+nx(ncur)+ux(ncur)
slocyt=slocyt+ny(ncur)+uy(ncur)
secx=secx+nx(ncur)
secy=secy+ny(ncur)
nsel,u,,,ncur
*enddo
rsys,45
slocx=slocxt/ncount
slocy=slocyt/ncount
xbar=-secx/ncount
ybar=secy/ncount
cmse,,sectn

spoi,,slocx,slocy
fsum,rsys
!*** Sum moments about neutral axis
*if,k,gt,18,and,k,lt,23,then
 *get,mzn,fsum,,item,mz
  flag=1
  *if,mzn,gt,0,then
   flag=-1
  *endif
   *if,k,eq,19,then
    slocx=slocx+flag*.85*cos(thd1)
    slocy=slocy+flag*.85*sin(thd1)
   *elseif,k,eq,20
    slocx=slocx+flag*.8*cos(thd1)
    slocy=slocy+flag*.8*sin(thd1)
   *elseif,k,eq,21
    slocx=slocx+flag*.82*cos(thd1)
    slocy=slocy+flag*.82*sin(thd1)
   *else
    slocx=slocx+flag*.77*cos(thd1)
    slocy=slocy+flag*.77*sin(thd1)
   *endif
*endif
spoi,,slocx,slocy
fsum,rsys

*get,smeru,fsum,,item,fx
*get,pmeru,fsum,,item,fy
*get,mmeru,fsum,,item,mz
*get,tmin,path,,min,temp
*get,tmax,path,,max,temp
*get,ttot,path,,last,itemp
esel,,type,,12,15
cmse,u,upper
fsum
```

```
*get,smerl,fsum,,item,fx
*get,pmerl,fsum,,item,fy
*get,mmerl,fsum,,item,mz
smer=(smeru-smerl)/2
pmer=(pmeru-pmerl)/2
mmer=(mmeru-mmerl)/2

!** Calculate hoop area
esln
esel,r,type,,12,15
*if,i,eq,4,then
esel,a,,,8478
*elseif,i,eq,6,then
esel,u,,,9378,9479,101
*endif
nsle
nsel,r,loc,z
*get,ecount,elem,,count
hparea=0
*do,j,1,ecount
ecur=elnext(j)
hparea=hparea+arface(ecur)
esel,u,,,ecur
*enddo
hparea=hparea/2
hpw=hparea/delt

esel,,type,,12,15
cmse,,sectn
fsum,rsys
*get,php,fsum,,item,fz
*get,mhp,fsum,,item,my

secw=xbar*swp_th/2*pi/180
tave=ttot/delt
smer=smer/secw*12/1000
pmer=pmer/secw*12/1000
mmer=-mmer/secw/1000
php=php/hpw*12/1000
mhp=mhp/hpw/1000

*vwri,k,smer,pmer,mmer,php,mhp,tmin,tmax,tave,xbar,ybar,
delt
(11f8.1,f8.2)
*enddo

!***
!*** Wall

csys
esel,,type,,12,15
nsle

*do,i,1,23
k=k+1
esel,,type,,12,15
,u,type,,14
nsle
csys
x1=-480
y1=wh(i)
x2=-498
```

```
y2=wh(i)

path,sect %k%,2,,200
ppat,1,,x1,y1
,2,,x2,y2

nsel,r,loc,y,h2,599
nsel,r,loc,y,wh(i)-3,599
esln,,1
esel,r,type,,12,15
*if,i,eq,2,then
esel,a,,,11133
*elseif,i,eq,3,then
esel,a,,,8559,11138,2579
*elseif,i,eq,4,then
esel,a,,,10972
*elseif,i,eq,8,then
esel,a,,,8590
*elseif,i,eq,9,then
esel,a,,,11091,11257,166
*elseif,i,eq,10,then
esel,a,,,8604,11098,2494
*elseif,i,eq,11,then
esel,a,,,11242
*elseif,i,eq,12,then
esel,a,,,11238
*elseif,i,eq,14,then
esel,a,,,11087,11229,142
*elseif,i,eq,15,then
esel,a,,,11156,11223,67
*elseif,i,eq,16,then
esel,a,,,11158,11221,63
*elseif,i,eq,17,then
esel,a,,,11213
*elseif,i,eq,18,then
esel,a,,,11173
*elseif,i,eq,19,then
esel,a,,,10931,11048,117
*elseif,i,eq,20,then
esel,a,,,11194
*endif
cm,upper,elem

rsys
pdef,temp,bfe,temp
pcalc,intg,itemp,temp,s
*get,delt,path,,last,s

nsel,r,loc,y,wh(i)-3,wh(i)
,r,loc,z
,r,loc,x,-498,-480
*get,ncount,node,,count
cm,sectn,node
slocxt=0
slocyt=0
secx=0
secy=0
csys
rsys
*do,j,1,ncount
ncur=ndnext(j)
slocxt=slocxt+nx(ncur)+ux(ncur)
```

```
slocyt=slocyt+ny(ncur)+uy(ncur)
secx=secx+nx(ncur)
secy=secy+ny(ncur)
nsel,u,,,ncur
*enddo
slocx=slocxt/ncount
slocy=slocyt/ncount
xbar=-secx/ncount
ybar=secy/ncount
cmse,,sectn
secw=xbar*swp_th/2*pi/180

spoi,,slocx,slocy
fsum,rsys
*get,smeru,fsum,,item,fx
*get,pmeru,fsum,,item,fy
*get,mmeru,fsum,,item,mz
*get,tmin,path,,min,temp
*get,tmax,path,,max,temp
*get,ttot,path,,last,itemp
esel,,type,,12,15
cmse,u,upper
fsum
*get,smerl,fsum,,item,fx
*get,pmerl,fsum,,item,fy
*get,mmerl,fsum,,item,mz
smer=(smeru-smerl)/2
pmer=(pmeru-pmerl)/2
mmer=(mmeru-mmerl)/2

!** Calculate hoop area
```

```
esln
esel,r,type,,12,15
*if,i,eq,2,then
esel,u,,,11134
*elseif,i,eq,3,then
esel,u,,,8558,11139,2581
*elseif,i,eq,4,then
esel,u,,,10973
*elseif,i,eq,8,then
esel,u,,,8591
*elseif,i,eq,9,then
esel,u,,,11092,11256,164
*elseif,i,eq,10,then
esel,u,,,8605,11106,2501
*elseif,i,eq,11,then
esel,u,,,11241
*elseif,i,eq,12,then
esel,u,,,11237
*elseif,i,eq,14,then
esel,u,,,11086,11228,142
*elseif,i,eq,15,then
esel,u,,,11157,11222,65
*elseif,i,eq,16,then
esel,u,,,11159,11220,61
*elseif,i,eq,17,then
esel,u,,,11212
*elseif,i,eq,18,then
esel,u,,,11174
*elseif,i,eq,19,then
esel,u,,,10930,11049,119
*elseif,i,eq,20,then
```

```
esel,u,,,11193
*endif
nsle
nsel,r,loc,z
*get,ecount,elem,,count
hparea=0
*do,j,1,ecount
ecur=elnext(j)
hparea=hparea+arface(ecur)
esel,u,,,ecur
*enddo
hparea=hparea/2
hpw=hparea/delt

esel,,type,,12,15
cmse,,sectn
fsum,rsys
*get,php,fsum,,item,fz
*get,mhp,fsum,,item,my

secw=xbar*swp_th/2*pi/180
tave=ttot/delt
smer=smer/secw*12/1000
pmer=pmer/secw*12/1000
mmer=-mmer/secw/1000
php=php/hpw*12/1000
mhp=mhp/hpw/1000

*vwri,k,smer,pmer,mmer,php,mhp,tmin,tmax,tave,xbar,ybar,
delt
(11f8.1,f8.2)
```

```
*enddo

!***
!*** Found

csys
esel,,type,,12,15
nsle
*do,i,1,16
k=k+1
esel,,type,,12,15
nsle
csys
x1=dsx(i)
*if,i,le,5,then
y1=-30.125
*elseif,i,le,9,then
y1=(ky(305)-ky(304))/(kx(305)-kx(304))*(-dsx(i)-
kx(304))+ky(304)
*elseif,i,le,15,then
y1=-18.625
*elseif,i,eq,16,then
y1=(ky(303)-ky(302))/(kx(303)-kx(302))*(-dsx(i)-
kx(302))+ky(302)
*endif
x2=dsx(i)
y2=h2
*if,i,le,2,then
y2=-6.625
*endif
path,sect %k%,2,,200
```

```
ppat,1,,-x1,y1
,2,,-x2,y2
nsel,r,loc,y,-40,y2
nsel,r,loc,x,-dsx(i)-3,1
esln,,1
esel,r,type,,12,15
*if,i,eq,7,then
esel,a,,,12008
*elseif,i,eq,13,then
esel,a,,,12088
*elseif,i,eq,16,then
esel,a,,,11793,12283,490
*endif
cm,lower,elem

pdef,temp,bfe,temp
pcalc,intg,itemp,temp,s
*get,delt,path,,last,s

nsle
nsel,r,loc,x,-dsx(i)-3,-dsx(i)
,r,loc,z
*if,i,eq,6,then
nsel,u,,,9483
*elseif,i,eq,7,then
nsel,u,,,9344
*elseif,i,eq,16,then
nsel,a,,,281
*endif
*get,ncount,node,,count
cm,sectn,node
slocxt=0
slocyt=0
secx=0
secy=0
csys
rsys
*do,j,1,ncount
ncur=ndnext(j-1)
slocxt=slocxt+nx(ncur)+ux(ncur)
slocyt=slocyt+ny(ncur)+uy(ncur)
secx=secx+nx(ncur)
secy=secy+ny(ncur)
nsel,u,,,ncur
*enddo
slocx=slocxt/ncount
slocy=slocyt/ncount
xbar=-secx/ncount
ybar=secy/ncount
cmse,,sectn
secw=xbar*swp_th/2*pi/180

spoi,,slocx,slocy
fsum
*get,smerl,fsum,,item,fy
*get,pmerl,fsum,,item,fx
*get,mmerl,fsum,,item,mz
*get,tmin,path,,min,temp
*get,tmax,path,,max,temp
*get,ttot,path,,last,itemp
esel,,type,,12,15
cmse,u,lower
```

```
fsum
*get,smeru,fsum,,item,fy
*get,pmeru,fsum,,item,fx
*get,mmeru,fsum,,item,mz
smer=(smerl-smeru)/2
pmer=(pmerl-pmeru)/2
mmer=(mmeru-mmerl)/2

!** Calculate hoop area
esln
esel,r,type,,12,15
*if,i,eq,6,then
esel,u,,,12148
*elseif,i,eq,7,then
esel,u,,,11797,12007,210
*elseif,i,eq,13,then
esel,u,,,12101
*endif
nsle
nsel,r,loc,z
*get,ecount,elem,,count
hparea=0
*do,j,1,ecount
ecur=elnext(j)
hparea=hparea+arface(ecur)
esel,u,,,ecur
*enddo
hparea=hparea/2
hpw=hparea/delt

esel,,type,,12,15
cmse,,sectn
fsum,rsys
*get,php,fsum,,item,fz
*get,mhp,fsum,,item,mx

tave=ttot/delt
smer=smer/secw*12/1000
pmer=pmer/secw*12/1000
mmer=-mmer/secw/1000
php=php/hpw*12/1000
mhp=mhp/hpw/1000

*vwri,k,smer,pmer,mmer,php,mhp,tmin,tmax,tave,xbar,ybar,
delt
(11f8.1,f8.2)
*enddo

*cfc
*enddo
```

Input file: postprimcomb.inp

```
/post1
set,109
lcwr,1

loca,199,1,,280.75,,90
esel,,,,15264,15276,12
,a,,,15303,15324,21
,a,,,15247,15258,11
,a,,,15211,15227,16
,a,,,15185,15197,12
```

```
,a,,,15167,15178,11
,a,,,15154,15161,7
,a,,,15140,15147,7
,a,,,15127,15134,7
,a,,,15115,15120,5
,a,,,15097,15109,6
,a,,,15076,15097,7
,a,,,15064,15070,6
,a,,,15054,15061,7
,a,,,15021,15042,21
,a,,,14999
rsys,solu

*do,k,95,108
set,k
lcop,sub,1
shel,top
ETAB,sintt,s,int
ETAB,locy,cent,y
shel,bot
ETAB,sintb,s,int
ETAB,locy,cent,y
esor,etab,locy,1
/out,primsec%k%,lis
PRET,locy,sintt,sintb
/out
*enddo
```

Input file: postprimcomb1.inp

```
/post1
set,109
loca,199,1,,280.75,,90
esel,,,,15264,15276,12
,a,,,15303,15324,21
,a,,,15247,15258,11
,a,,,15211,15227,16
,a,,,15185,15197,12
,a,,,15167,15178,11
,a,,,15154,15161,7
,a,,,15140,15147,7
,a,,,15127,15134,7
,a,,,15115,15120,5
,a,,,15097,15109,6
,a,,,15076,15097,7
,a,,,15064,15070,6
,a,,,15054,15061,7
,a,,,15021,15042,21
,a,,,14999
rsys,solu
shel,mid
etab,sxm,s,x
ETAB,sym,s,y
ETAB,sxym,s,xy
ETAB,sintm,s,int
ETAB,locy,cent,y
shel,top
etab,sxt,s,x
ETAB,syt,s,y
ETAB,sxyt,s,xy
ETAB,sintt,s,int
ETAB,locy,cent,y
```

```
shel,bot
etab,sxb,s,x
ETAB,syb,s,y
ETAB,sxyb,s,xy
ETAB,sintb,s,int
ETAB,locy,cent,y
pret,locy,sxm,sym,sxym,sintm
PRET,locy,sxt,syt,sxyt,sintt
PRET,locy,sxb,syb,sxyb,sintb
```

Input file: postseccomb.inp

```
/post1
csys

esel,,,,15185,15211,26
,a,,,15227,15247,20
,a,,,15258,15264,6
,a,,,15276,15798,522
,a,,,15303,15324,21
,a,,,15804,15814,10
,a,,,15654,15666,12
,a,,,15687,15708,21
,a,,,15723,15737,14
,a,,,15750,15953,203
,a,,,15785,15788,3
,a,,,15819,15837,18
,a,,,15851,15866,15
,a,,,15877,15897,20
,a,,,15795,15912,117
,a,,,15764
loca,199,1,,280.75,,90

*do,k,95,109
set,k
etab,locy,cent,y
shel,mid
etab,epstm,epto,1
,epscm,epto,3
sadd,epscm,epscm,,-1
shel,top
etab,epstbt,epto,1
,epscbt,epto,3
sadd,epscbt,epscbt,,-1
shel,bot
etab,epstbb,epto,1
,epscbb,epto,3
sadd,epscbb,epscbb,,-1
esor,etab,locy,1
/out,combsl%k%,lis
pret,locy,epstm,epscm,epstbt,epscbt,epstbb,epscbb
/out
*enddo
```

Input file: jbolt2.inp

```
!*** J-bolts
!*** 6/1/04

!***

!***  writes data for all laod steps in a single file! modified
09/02/04 - Siva!
```

```
!***  NB!! 6/1/04
!***   This version uses (sfyi**2+sfzi**2)**1/2
!***   because beams on z <> 0 face are
!***   incorrectly oriented (should use nod1k in
set_slicea.mac)
!***



/fil,set_slice_0
resu
/post1

*do,k,95,99

set,k

*cfo,lsteps,asme,,append

tt1='Load Step'

*vwri,tt1
%c

*vwri,k
(11f8.1,f8.1)

ct='J-bolt pos'
ct1='F-axial'
ct2='F-shear'
ct3='U-axial'
ct4='U-shear'

*vwri,ct,ct1,ct2,ct3,ct4
(12a12)

esel,,real,,50,56
nsle
esln
esel,r,type,,30
nsle
etab,fxi,smisc,1
,sfyi,smisc,6
,sfzi,smisc,5
,exi,smisc,7
,esyi,smis,12
,eszi,smis,11
csys,1
etab,jloc,cent,y
esor,etab,jloc,1
*dim,faxial,,13
,fshear,,13
,uaxial,,13
,ushear,,13
*do,i,1,13
*get,e1,sort,,imin
*get,fx1,elem,e1,etab,fxi
*get,fsheary1,elem,e1,etab,sfyi
*get,fshearz1,elem,e1,etab,sfzi
*get,ex1,elem,e1,etab,exi
*get,esheary1,elem,e1,etab,esyi
*get,eshearz1,elem,e1,etab,eszi
```

```
esel,u,,,e1
esor,etab,jloc,1
*get,e2,sort,,imin
*get,fx2,elem,e2,etab,fxi
*get,fsheary2,elem,e2,etab,sfyi
*get,fshearz2,elem,e2,etab,sfzi
*get,ex2,elem,e2,etab,exi
*get,esheary2,elem,e2,etab,esyi
*get,eshearz2,elem,e2,etab,eszi
faxial(i)=fx1+fx2
fsheary=(fsheary1**2+fshearz1**2)**0.5
fshearz=(fsheary2**2+fshearz2**2)**0.5
fshear(i)=fsheary+fshearz
uaxial(i)=(ex1*4+ex2*4)/2          !** 4" J-bolt length
usheary=(esheary1**2+eshearz1**2)**0.5
ushearz=(esheary2**2+eshearz2**2)**0.5
ushear(i)=(usheary*4+ushearz*4)/2
esel,u,,,e2
esor,etab,jloc,1

fax=faxial(i)
fsh=fshear(i)
uax=uaxial(i)
ush=ushear(i)

*vwri,i,fax,fsh,uax,ush
(12g12.5,g12.5)

*enddo

*cfc

  *enddo
```

E.4 Anchor Bolt Reanalysis Model Input Files

E.4.1 Model files

Input file: set_slicea.mac (Lower bound secant stiffness)

```
!***
!***    47 kips/in axial & shear stiffness   4/17/08
!***    Mu = 0.01  Dome    4/8/08
!***    Additional contact primary <> concrete   4/8/08
!***    Revise axial anchor spring orientation    4/8/08
!***    47K Secant modulus anchor bolts 3/4/08
!***    2nd liner extension 0.25 thick                7/21/04
!***    2nd liner extension contact <> concrete   7/21/04
!***    Augmented stiffness 5% Econc (350)    7/19/04
!***    5% pivot, bcso,mmd       6/25/04
!***    Use nsub                 6/24/04
!***    cnvtol,f(m),,.005,0      6/16/04
!***    Augmented stiffness 2% Econc (350)   6/14/04
!***    Augmented stiffness 30000   6/11/04
!***    6/10/04 changes
!***       Do not merge insulating concrete <> 2nd liner @ OD
of concrete
!***       Add 1st radius element to contact of 1st liner <> ins
conc
!***       Add contact 2nd liner <> slab concrete
!***    Correct node select for type,61 real,70   6/9/04
```

```
!***    Reorient Beam188 on z=/= 0 face
!***    Fix Liner-Dome common nodes   5/6/04
!***    Delete "j-bolts" in wall    5/6/04
!***    Move j-bolt real definition to pnnla6.mac  3/30/04
!***    Changed Liner Coupling per J. Deibler 3/29/04
!!***   Augmented stiffness 15000   3/24/04
!***    Default convergence criteria  3/22/04
!***    Best estimate soil properties  3/19/04
!***    Soil-Concrete - 5 regions  2/23/04
!***    Correct Drucker-Prager - soil
!***    Correct mat,1 temperature dependent modulus
!***    Replace shell64 with shell181
!***    Primary tank pressure -12" H2O (was -6)
!***    125 pcf overburden, 110 pcf undisturbed soil
!***    10/30/03
!***    Define additional soils for load factor restart
!***    No cracking insulating concrete
!***    fix mpch (esel,r,mat,,2)
!***    1 yr + 15 day creep  5/14/03
!***   Load step 5 creep for 330 days
!***    New load step 6 => mpch +5 days
!***      "sets" degraded concrete properties
!***
!***  Turn off concrete crushing 5/5/03
!***
!*** Run 2, Load Step 1, 2 & thermal
!***  (8.3' soil, 125 lb/ft3)
!***  (0.06" primary tank corrosion wall, floor)
!*** 4/16/03
!***
!***
```

```
!*** JED mods 3/29/03
!***

i_rebuild=1
*if,i_rebuild,eq,1,then
    pnnla
    pnnla2
    pnnla3
    pnnla4
    pnnla5
    pnnla6
    pnnla7
    pnnla8
    pnnla9
*else
    resume,pnnla9,db
*endif

/prep7

allsel
cpdele,all,all

!get misc area components for applying loads, etc.
/input,set_areas_slice,mac

!add steel plate below wall (on slab)
r,45,1/4
csys,22
vsel,s,mat,,2
aslv
```

```
asel,r,loc,z,-8.125
asel,r,loc,x,480,498
aatt,1,45,22
mat,1
real,45
amesh,all

!define contact elements (all have default friction of 0.3)
et,60,170
et,61,173
mp,mu,61,.3             !Soil-concrete dome
,mu,62,.4
,mu,63,.01      !4/8/08
,mu,64,.4
,mu,65,.3
,mu,66,.2
,mu,67,.05      !soil-concrete wall
,mu,68,.3       !soil-concrete footing/top
,mu,69,.05      !soil-concrete footing/side
,mu,70,.6       !soil-concrete foundation
,mu,71,.4       !2nd liner-insulating concrete 6/10/04

!soil_concrete contact - dome
r,61,,,1,.1
real,61
type,61
mat,61
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,z,452,600
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,452,600
esln
esurf

!soil_concrete contact - wall
r,67,,,1,.1
real,67
type,61
mat,67
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,z,-3,453
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,-3,453
esln
esurf

!soil_concrete contact - Footing - top
r,68,,,1,.1
real,68
type,61
mat,68
cmsel,s,aconc_soil
```

E.92

```
nsla,,1
nsel,r,loc,z,-7,-6
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,-7,-6
,r,loc,x,496,530
esln
esurf

!soil_concrete contact - Footing - side
r,69,,,1,.1
real,69
type,61
mat,69
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,x,531
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,x,531
esln
esurf

!soil_concrete contact - Foundation
r,70,,,1,.1
real,70
type,61
mat,70
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,z,-31,-30
,r,loc,x,440,531
cm,foundconc,node
nsla,,1
nsel,r,loc,x,,440
,r,loc,z,-33,-8                !** was -32  6/9/04
cmse,a,foundconc
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,-31,-30
,r,loc,x,440,531
cm,foundsoil,node
nsla,,1
nsel,r,loc,x,,440
,r,loc,z,-33,-8
cmse,a,foundsoil
esln
esurf

!secondary liner contact
r,62,,,1,.1
real,62
type,60
```

```
mat,62
cmsel,s,aconc_shell
csys,0
asel,u,loc,y,459,99999
nsla,,1
esln
esel,r,mat,,2
esurf
type,61
cmsel,s,area_secon
csys,0
asel,u,loc,y,-99999,3.87
nsla,,1
esln
esurf

!primary liner contact with dome
r,63,,,1,.1
real,63
type,60
mat,63
cmsel,s,aconc_shell
asel,r,loc,y,450,999        !* 4/8/08
nsla,,1
esln
esel,r,mat,,2
esurf
type,61
cmsel,s,area_prim
asel,r,loc,y,440,999        !* 4/8/08
nsla,,1
esln
esurf

!primary liner contact with insulating concrete
r,64,,,1,.1
real,64
type,60
mat,64
cmsel,s,area_insul_top
nsla,,1
esln
esel,r,mat,,4
esurf
type,61
cmsel,s,area_prim
csys,0
asel,r,loc,y,0
nsla,,1
esln
nsle      !*6/10/04
esurf

!secondary liner contact with foundation concrete  6/10/04
r,71,,,1,.1
real,71
type,60
mat,71
cmse,,slab_top
asel,r,loc,x,-480,-440
nsla,,1
esln
```

```
esur
type,61
cmse,,area_secon
asel,r,loc,x,-470,-440
,r,loc,y,-9,-8
nsla,,1
esln
nsle
esur

!merge insulating concrete bottom nodes and secondary liner
nodes
cmsel,s,area_insul_bot
cmsel,a,area_secon
csys,0
asel,u,loc,y,20,9999
nsla,,1
cpintf,uz,.1

!slab top/insulating concrete
r,65,,,1,.1
real,65
type,60
mat,65
cmsel,s,slab_top
nsla,,1
esln
esurf
type,61
cmsel,s,area_insul_bot
nsla,,1
esln
esurf

!wall/slab contact
r,66,,,1,.1
real,66
type,60
mat,66
asel,,,,986,992
cm,slab_top_wall,area
nsla,,1
esln
esel,r,mat,,2
esurf
type,61
asel,,,,214
,a,,,706
,a,,,913,918,5
,a,,,934
cm,wall_bot,area
nsla,,1
esln
esel,r,mat,,2
esurf

allsel
!esel,s,type,,60
!nsle
!nummrg,node
!nummrg,elem
!esel,s,type,,61
```

```
!nsle
!nummrg,elem

max_mat=100
max_real=1000

!define the local coordinate systems and rebar orientations
/input,set_esys_3d,mac

!apply loads
/input,apply_loads_slice,mac
allsel

!apply axisymmetric boundary conditions
csys,22
nsel,s,loc,y,180
nsel,a,loc,y,180+swp_th-.001,183
csys,0
nsel,a,loc,x,0
d,all,uy,0
d,all,rotx,0
d,all,rotz,0
allsel

nsel,s,loc,x,0
d,all,roty,0

!merge liner/concrete nodes at dome centerline
ksel,s,,,2
ksel,a,,,329
nslk
nummrg,node
allsel

!copy jbolts, etc for slice model
csys,22
esel,s,type,,20,21
cm,e_bolt0,elem
egen,2,500000,all,,,0,0,0,0,0,,swp_th
esel,s,mat,,1
esel,u,real,,45
nsle
nsel,u,,,22789,22790     !*** 5/6/04
,u,,,20260,20261         !*** 6/10/04
nummrg,node

!divide jbolt/bottom anchors properties by 2 for slice model
r,30,.19635/2,.3068e-2/2,.3068e-2/2,.5,.5

esel,s,type,,20,21
cmsel,u,e_bolt0
nsle
nsel,r,,,500000,999999
cm,ntemp,node

vsel,s,mat,,2
vsel,a,mat,,6
csys,0
vsel,u,loc,y,-9999,-8.12
cm,vtemp,volu
*get,nv,volu,,count
*do,i,1,nv
```

```
     *get,iv,volu,,num,min
     eslv
     nsle
     cmsel,a,ntemp
     nummrg,node
     cm,ntemp,node
     cmsel,s,vtemp
     vsel,u,,,iv
     cm,vtemp,volu
*enddo

!***
!***  Delete primary-secondary tank coupling at tangent
!***   JED 3/31/03
!***

r,41,3/16          !insulating concrete confining ring thickness

/prep7

esel,s,mat,,5
nsle,,1
csys,0
*get,top_elev,node,,mxloc,y
cm,soil_elem,elem

*do,i,1,16
     set_slayer,soil_z0(i),soil_z1(i),soil_emod(i),soil_pr(i)
*enddo

max_mat=100

!set backfill/overburden material
*do,i,1,8
     set_backfill,bf_z0(i),bf_z1(i),bf_emod(i),bf_pr
*enddo

!Don't do this!! 5/6/04
!make sure anchors/jbolts/studs etc are merged with concrete
!esel,,type,,12,13
!,a,type,,20,21
!,a,type,,24,25
!nsle
!nsel,u,,,22789,22790    !*** 3/26/04
!numm,node

!***
!***     Augmented Stiffness  2/27/04
!***
et,32,45
*get,ec350,ex,2,temp,350
mp,ex,12,ec350*0.05               !7/19/04
,prxy,12,.15
esel,,type,,12,15
egen,2,0,all,,,10
esel,,mat,,12
emod,all,type,32

/fil,set_slice_0

!***
!***     Use springs for anchor bolts  8/9/07
!***
```

```
alls
csys
et,35,40,,,2                 !Anchor bolt axial
,36,40,,,1                   !Anchor bolt shear
*do,i,1,18
r,i,i*24*2*pi/24*swp_th/360*47000/2   !47K  -shear  3/4/08
r,80+i,i*24*2*pi/24*swp_th/360*47000/2        !47K  -axial
4/17/08
*enddo

csys,11
nsel,,loc,x,480-.5,480+.5
cm,ancb,node
loca,99,,,,,,,swp_th
csys
*do,i,1,15
cmse,,ancb
csys
nsel,r,loc,z
,r,loc,x,-i*24-1.5,-i*24+1.5
type,35
real,80+i
drot=atan(-nx(ndnext(1))*180/480/(480**2-
nx(ndnext(1))**2)**.5)
loca,50+i,,nx(ndnext(1)),ny(ndnext(1)),,drot
nrot,all
e,ndnext(ndnext(0)),ndnext(0)
type,36
real,i
e,ndnext(0),ndnext(ndnext(0))
*enddo
*do,i,16,18
cmse,,ancb
csys
nsel,r,loc,z
,r,loc,x,-i*24-.5,-i*24+1.5
type,35
real,80+i
drot=atan(-nx(ndnext(1))*180/480/(480**2-
nx(ndnext(1))**2)**.5)
loca,50+i,,nx(ndnext(1)),ny(ndnext(1)),,drot
nrot,all
e,ndnext(ndnext(0)),ndnext(0)
type,36
real,i
e,ndnext(0),ndnext(ndnext(0))
*enddo
*do,i,1,15
cmse,,ancb
csys
nsel,u,loc,z
,r,loc,x,-i*24-1.4,-i*24+1.5
type,35
real,80+i
drot=atan(-nx(ndnext(1))*180/480/(480**2-
nx(ndnext(1))**2)**.5)
csys,99
cloc,70+i,,nx(ndnext(1)),ny(ndnext(1)),,drot
nrot,all
e,ndnext(ndnext(0)),ndnext(0)
type,36
```

```
real,i
e,ndnext(0),ndnext(ndnext(0))
*enddo
*do,i,16,18
cmse,,ancb
csys
nsel,u,loc,z
,r,loc,x,-i*24,-i*24+2
type,35
real,80+i
drot=atan(-nx(ndnext(1))*180/480/(480**2-
nx(ndnext(1))**2)**.5)
csys,99
cloc,70+i,,nx(ndnext(1)),ny(ndnext(1)),,drot
nrot,all
e,ndnext(ndnext(0)),ndnext(0)
type,36
real,i
e,ndnext(0),ndnext(ndnext(0))
*enddo
!*** Fix BC
esel,,type,,35
nsle
ddel,all,all
d,all,uz
,all,rotx
,all,roty

allsel
```

```
!***  2nd liner extension issues   7/21/04
asel,,,,928,,1
egen,2,100000,all,,,,,4,,,0,0,0
modm,nocheck
alls
emod,15784,-1,114183,104465
,15955,-3,104465,114183
,28878,-3,104465,114183
acle,928
real,62
type,60
mat,62
asel,,,,928,,1
esln
esel,r,type,,12
esurf
type,61
esel,,type,,23
,r,real,,45
nsle
esurf
dsym,symm,y,5
alls

!***
!***   Temperatures
!***     Uniform 50F  (4/17/03)
!***
tref,80
tunif,80
```

```
finish
/filnam,set_slice_0
/sol
!solcontrol,off
neqit,50
time,1
nlgeom,on
nrop,unsym
cnvt,f,,.005,0              !6/16/04
,m,,.005,0          !6/16/04
crpl,.05
nsub,10,100,5
!delt,.1,.01,.2
!outres,all,all
!nrre,on,250
eqsl,sparse,.05,-1
bcso,mmd
allsel
save
solve

time,2
!***
!*** Add waste and pressure loads
!***
pres_surf=0             !ground surface uniform pressure psf
point_cent=0            !point load at center lb
pres_annulus=-20        !annulus pressure inches h2o
pres_int=-12            !annulus internal pressure inches h2o
hwaste=35.17*12                 !total waste height
height_waste1=hwaste/3          !height of waste 1 inches
gamma_waste1=1.7                !specific gravity of waste 1
height_waste2=hwaste/3          !height of waste 2 inches
gamma_waste2=1.7                !specific gravity of waste 2
height_waste3=hwaste/3          !height of waste 3 inches
gamma_waste3=1.7                !specific gravity of waste 3

/inp,apply_loads_slice,mac

delt,.1,.01,.25
solv

time,3
!***
!*** Add surface loads
!***
pres_surf=40            !ground surface uniform pressure psf
point_cent=200000       !point load at center lb
pres_annulus=-20        !annulus pressure inches h2o
pres_int=-12            !annulus internal pressure inches h2o
hwaste=35.17*12                 !total waste height
height_waste1=hwaste/3          !height of waste 1 inches
gamma_waste1=1.7                !specific gravity of waste 1
height_waste2=hwaste/3          !height of waste 2 inches
gamma_waste2=1.7                !specific gravity of waste 2
height_waste3=hwaste/3          !height of waste 3 inches
gamma_waste3=1.7                !specific gravity of waste 3

/inp,apply_loads_slice,mac

save
solv
```

Input file: set_slicea.mac (Upper bound secant stiffness)

```
!***
!***     90 kips/in axial & shear stiffness   4/17/08
!***     Mu = 0.01  Dome    4/8/08
!***     Additional contact primary <> concrete   4/8/08
!***     Revise axial anchor spring orientation    4/8/08
!***     47K Secant modulus anchor bolts 3/4/08
!***     2nd liner extension 0.25 thick                 7/21/04
!***     2nd liner extension contact <> concrete   7/21/04
!***     Augmented stiffness 5% Econc (350)   7/19/04
!***     5% pivot, bcso,mmd       6/25/04
!***     Use nsub                 6/24/04
!***     cnvtol,f(m),,.005,0      6/16/04
!***     Augmented stiffness 2% Econc (350)   6/14/04
!***     Augmented stiffness 30000   6/11/04
!***     6/10/04 changes
!***        Do not merge insulating concrete <> 2nd liner @ OD
of concrete
!***        Add 1st radius element to contact of 1st liner <> ins
conc
!***        Add contact 2nd liner <> slab concrete
!***     Correct node select for type,61 real,70   6/9/04
!***     Reorient Beam188 on z=/= 0 face
!***     Fix Liner-Dome common nodes   5/6/04
!***     Delete "j-bolts" in wall    5/6/04
!***     Move j-bolt real definition to pnnla6.mac  3/30/04
!***     Changed Liner Coupling per J. Deibler 3/29/04
!!***    Augmented stiffness 15000   3/24/04
!***     Default convergence criteria  3/22/04
!***     Best estimate soil properties  3/19/04
!***     Soil-Concrete - 5 regions  2/23/04
!***     Correct Drucker-Prager - soil
!***     Correct mat,1 temperature dependent modulus
!***     Replace shell64 with shell181
!***     Primary tank pressure -12" H2O (was -6)
!***     125 pcf overburden, 110 pcf undisturbed soil
!***     10/30/03
!***     Define additional soils for load factor restart
!***     No cracking insulating concrete
!***     fix mpch (esel,r,mat,,2)
!***     1 yr + 15 day creep  5/14/03
!***    Load step 5 creep for 330 days
!***     New load step 6 => mpch +5 days
!***       "sets" degraded concrete properties
!***
!***   Turn off concrete crushing 5/5/03
!***
!*** Run 2, Load Step 1, 2 & thermal
!***   (8.3' soil, 125 lb/ft3)
!***   (0.06" primary tank corrosion wall, floor)
!*** 4/16/03
!***
!***
!*** JED mods 3/29/03
!***

i_rebuild=1
*if,i_rebuild,eq,1,then
    pnnla
    pnnla2
```

```
     pnnla3
     pnnla4
     pnnla5
     pnnla6
     pnnla7
     pnnla8
     pnnla9
*else
     resume,pnnla9,db
*endif

/prep7

allsel
cpdele,all,all

!get misc area components for applying loads, etc.
/input,set_areas_slice,mac

!add steel plate below wall (on slab)
r,45,1/4
csys,22
vsel,s,mat,,2
aslv
asel,r,loc,z,-8.125
asel,r,loc,x,480,498
aatt,1,45,22
mat,1
real,45
amesh,all
```

```
!define contact elements (all have default friction of 0.3)
et,60,170
et,61,173
mp,mu,61,.3              !Soil-concrete dome
,mu,62,.4
,mu,63,.01       !4/8/08
,mu,64,.4
,mu,65,.3
,mu,66,.2
,mu,67,.05       !soil-concrete wall
,mu,68,.3        !soil-concrete footing/top
,mu,69,.05       !soil-concrete footing/side
,mu,70,.6        !soil-concrete foundation
,mu,71,.4        !2nd liner-insulating concrete 6/10/04

!soil_concrete contact - dome
r,61,,,1,.1
real,61
type,61
mat,61
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,z,452,600
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,452,600
esln
esurf
```

```
!soil_concrete contact - wall
r,67,,,1,.1
real,67
type,61
mat,67
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,z,-3,453
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,-3,453
esln
esurf

!soil_concrete contact - Footing - top
r,68,,,1,.1
real,68
type,61
mat,68
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,z,-7,-6
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,-7,-6
,r,loc,x,496,530
esln
esurf

!soil_concrete contact - Footing - side
r,69,,,1,.1
real,69
type,61
mat,69
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,x,531
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,x,531
esln
esurf

!soil_concrete contact - Foundation
r,70,,,1,.1
real,70
type,61
mat,70
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,z,-31,-30
,r,loc,x,440,531
```

```
cm,foundconc,node
nsla,,1
nsel,r,loc,x,,440
,r,loc,z,-33,-8              !** was -32  6/9/04
cmse,a,foundconc
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,-31,-30
,r,loc,x,440,531
cm,foundsoil,node
nsla,,1
nsel,r,loc,x,,440
,r,loc,z,-33,-8
cmse,a,foundsoil
esln
esurf

!secondary liner contact
r,62,,,1,.1
real,62
type,60
mat,62
cmsel,s,aconc_shell
csys,0
asel,u,loc,y,459,99999
nsla,,1
esln
esel,r,mat,,2
esurf
type,61
cmsel,s,area_secon
csys,0
asel,u,loc,y,-99999,3.87
nsla,,1
esln
esurf

!primary liner contact with dome
r,63,,,1,.1
real,63
type,60
mat,63
cmsel,s,aconc_shell
asel,r,loc,y,450,999       !* 4/8/08
nsla,,1
esln
esel,r,mat,,2
esurf
type,61
cmsel,s,area_prim
asel,r,loc,y,440,999       !* 4/8/08
nsla,,1
esln
esurf

!primary liner contact with insulating concrete
r,64,,,1,.1
real,64
type,60
```

```
mat,64
cmsel,s,area_insul_top
nsla,,1
esln
esel,r,mat,,4
esurf
type,61
cmsel,s,area_prim
csys,0
asel,r,loc,y,0
nsla,,1
esln
nsle      !*6/10/04
esurf

!secondary liner contact with foundation concrete  6/10/04
r,71,,,1,.1
real,71
type,60
mat,71
cmse,,slab_top
asel,r,loc,x,-480,-440
nsla,,1
esln
esur
type,61
cmse,,area_secon
asel,r,loc,x,-470,-440
,r,loc,y,-9,-8
nsla,,1
esln
nsle
esur

!merge insulating concrete bottom nodes and secondary liner
nodes
cmsel,s,area_insul_bot
cmsel,a,area_secon
csys,0
asel,u,loc,y,20,9999
nsla,,1
cpintf,uz,.1

!slab top/insulating concrete
r,65,,,1,.1
real,65
type,60
mat,65
cmsel,s,slab_top
nsla,,1
esln
esurf
type,61
cmsel,s,area_insul_bot
nsla,,1
esln
esurf

!wall/slab contact
r,66,,,1,.1
real,66
type,60
```

```
mat,66
asel,,,,986,992
cm,slab_top_wall,area
nsla,,1
esln
esel,r,mat,,2
esurf
type,61
asel,,,,214
,a,,,706
,a,,,913,918,5
,a,,,934
cm,wall_bot,area
nsla,,1
esln
esel,r,mat,,2
esurf

allsel
!esel,s,type,,60
!nsle
!nummrg,node
!nummrg,elem
!esel,s,type,,61
!nsle
!nummrg,elem

max_mat=100
max_real=1000

!define the local coordinate systems and rebar orientations
/input,set_esys_3d,mac

!apply loads
/input,apply_loads_slice,mac
allsel

!apply axisymmetric boundary conditions
csys,22
nsel,s,loc,y,180
nsel,a,loc,y,180+swp_th-.001,183
csys,0
nsel,a,loc,x,0
d,all,uy,0
d,all,rotx,0
d,all,rotz,0
allsel

nsel,s,loc,x,0
d,all,roty,0

!merge liner/concrete nodes at dome centerline
ksel,s,,,2
ksel,a,,,329
nslk
nummrg,node
allsel

!copy jbolts, etc for slice model
csys,22
esel,s,type,,20,21
cm,e_bolt0,elem
```

```
egen,2,500000,all,,,0,0,0,0,0,,swp_th
esel,s,mat,,1
esel,u,real,,45
nsle
nsel,u,,,22789,22790     !*** 5/6/04
,u,,,20260,20261         !*** 6/10/04
nummrg,node

!divide jbolt/bottom anchors properties by 2 for slice model
r,30,.19635/2,.3068e-2/2,.3068e-2/2,.5,.5

esel,s,type,,20,21
cmsel,u,e_bolt0
nsle
nsel,r,,,500000,999999
cm,ntemp,node

vsel,s,mat,,2
vsel,a,mat,,6
csys,0
vsel,u,loc,y,-9999,-8.12
cm,vtemp,volu
*get,nv,volu,,count
*do,i,1,nv
    *get,iv,volu,,num,min
    eslv
    nsle
    cmsel,a,ntemp
    nummrg,node
    cm,ntemp,node
    cmsel,s,vtemp
    vsel,u,,,iv
    cm,vtemp,volu
*enddo

!***
!***  Delete primary-secondary tank coupling at tangent
!***   JED 3/31/03
!***

r,41,3/16        !insulating concrete confining ring thickness

/prep7

esel,s,mat,,5
nsle,,1
csys,0
*get,top_elev,node,,mxloc,y
cm,soil_elem,elem

*do,i,1,16
    set_slayer,soil_z0(i),soil_z1(i),soil_emod(i),soil_pr(i)
*enddo

max_mat=100
!set backfill/overburden material
*do,i,1,8
    set_backfill,bf_z0(i),bf_z1(i),bf_emod(i),bf_pr
*enddo

!Don't do this!! 5/6/04
!make sure anchors/jbolts/studs etc are merged with concrete
```

E.107

```
!esel,,type,,12,13
!,a,type,,20,21
!,a,type,,24,25
!nsle
!nsel,u,,,22789,22790    !*** 3/26/04
!numm,node

!***
!***     Augmented Stiffness  2/27/04
!***
et,32,45
*get,ec350,ex,2,temp,350
mp,ex,12,ec350*0.05                !7/19/04
,prxy,12,.15
esel,,type,,12,15
egen,2,0,all,,,10
esel,,mat,,12
emod,all,type,32

/fil,set_slice_0

!***
!***     Use springs for anchor bolts  8/9/07
!***

alls
csys
et,35,40,,,2                   !Anchor bolt axial
,36,40,,,1                     !Anchor bolt shear
*do,i,1,18
r,i,i*24*2*pi/24*swp_th/360*90000/2    !90K  -shear  4/17/08
r,80+i,i*24*2*pi/24*swp_th/360*90000/2         !90K  -axial
4/17/08
*enddo

csys,11
nsel,,loc,x,480-.5,480+.5
cm,ancb,node
loca,99,,,,,,,swp_th
csys
*do,i,1,15
cmse,,ancb
csys
nsel,r,loc,z
,r,loc,x,-i*24-1.5,-i*24+1.5
type,35
real,80+i
drot=atan(-nx(ndnext(1))*180/480/(480**2-
nx(ndnext(1))**2)**.5)
loca,50+i,,nx(ndnext(1)),ny(ndnext(1)),,drot
nrot,all
e,ndnext(ndnext(0)),ndnext(0)
type,36
real,i
e,ndnext(0),ndnext(ndnext(0))
*enddo
*do,i,16,18
cmse,,ancb
csys
nsel,r,loc,z
,r,loc,x,-i*24-.5,-i*24+1.5
type,35
```

E.108

```
real,80+i
drot=atan(-nx(ndnext(1))*180/480/(480**2-
nx(ndnext(1))**2)**.5)
loca,50+i,,nx(ndnext(1)),ny(ndnext(1)),,drot
nrot,all
e,ndnext(ndnext(0)),ndnext(0)
type,36
real,i
e,ndnext(0),ndnext(ndnext(0))
*enddo
*do,i,1,15
cmse,,ancb
csys
nsel,u,loc,z
,r,loc,x,-i*24-1.4,-i*24+1.5
type,35
real,80+i
drot=atan(-nx(ndnext(1))*180/480/(480**2-
nx(ndnext(1))**2)**.5)
csys,99
cloc,70+i,,nx(ndnext(1)),ny(ndnext(1)),,drot
nrot,all
e,ndnext(ndnext(0)),ndnext(0)
type,36
real,i
e,ndnext(0),ndnext(ndnext(0))
*enddo
*do,i,16,18
cmse,,ancb
csys
nsel,u,loc,z
,r,loc,x,-i*24,-i*24+2
type,35
real,80+i
drot=atan(-nx(ndnext(1))*180/480/(480**2-
nx(ndnext(1))**2)**.5)
csys,99
cloc,70+i,,nx(ndnext(1)),ny(ndnext(1)),,drot
nrot,all
e,ndnext(ndnext(0)),ndnext(0)
type,36
real,i
e,ndnext(0),ndnext(ndnext(0))
*enddo
!*** Fix BC
esel,,type,,35
nsle
ddel,all,all
d,all,uz
,all,rotx
,all,roty

allsel

!***  2nd liner extension issues   7/21/04
asel,,,,928,,1
egen,2,100000,all,,,,,4,,,0,0,0
modm,nocheck
alls
emod,15784,-1,114183,104465
,15955,-3,104465,114183
,28878,-3,104465,114183
```

```
acle,928
real,62
type,60
mat,62
asel,,,,928,,,1
esln
esel,r,type,,12
esurf
type,61
esel,,type,,23
,r,real,,45
nsle
esurf
dsym,symm,y,5
alls

!***
!***   Temperatures
!***     Uniform 50F  (4/17/03)
!***
tref,80
tunif,80

finish
/filnam,set_slice_0
/sol
!solcontrol,off
neqit,50
time,1
nlgeom,on
nrop,unsym
cnvt,f,,.005,0                !6/16/04
,m,,.005,0          !6/16/04
crpl,.05
nsub,10,100,5
!delt,.1,.01,.2
!outres,all,all
!nrre,on,250
eqsl,sparse,.05,-1
bcso,mmd
allsel
save
solve

time,2
!***
!***  Add waste and pressure loads
!***
pres_surf=0                 !ground surface uniform pressure psf
point_cent=0                !point load at center lb
pres_annulus=-20            !annulus pressure inches h2o
pres_int=-12                !annulus internal pressure inches h2o
hwaste=35.17*12                   !total waste height
height_waste1=hwaste/3            !height of waste 1 inches
gamma_waste1=1.7                  !specific gravity of waste 1
height_waste2=hwaste/3            !height of waste 2 inches
gamma_waste2=1.7                  !specific gravity of waste 2
height_waste3=hwaste/3            !height of waste 3 inches
gamma_waste3=1.7                  !specific gravity of waste 3

/inp,apply_loads_slice,mac
```

```
delt,.1,.01,.25
solv

time,3
!***
!*** Add surface loads
!***
pres_surf=40            !ground surface uniform pressure psf
point_cent=200000       !point load at center lb
pres_annulus=-20        !annulus pressure inches h2o
pres_int=-12            !annulus internal pressure inches h2o
hwaste=35.17*12                 !total waste height
height_waste1=hwaste/3          !height of waste 1 inches
gamma_waste1=1.7                !specific gravity of waste 1
height_waste2=hwaste/3          !height of waste 2 inches
gamma_waste2=1.7                !specific gravity of waste 2
height_waste3=hwaste/3          !height of waste 3 inches
gamma_waste3=1.7                !specific gravity of waste 3

/inp,apply_loads_slice,mac

save
solv
```

Input file: set_slicea.mac (Fully cracked secant stiffness)

```
!***
!***    23.5 kips/in axial & shear stiffness   4/17/08
!***    Mu = 0.01  Dome    4/8/08
!***    Additional contact primary <> concrete   4/8/08
!***    Revise axial anchor spring orientation    4/8/08
!***    47K Secant modulus anchor bolts 3/4/08
!***    2nd liner extension 0.25 thick                 7/21/04
!***    2nd liner extension contact <> concrete   7/21/04
!***    Augmented stiffness 5% Econc (350)   7/19/04
!***    5% pivot, bcso,mmd       6/25/04
!***    Use nsub                 6/24/04
!***    cnvtol,f(m),,.005,0      6/16/04
!***    Augmented stiffness 2% Econc (350)   6/14/04
!***    Augmented stiffness 30000   6/11/04
!***    6/10/04 changes
!***       Do not merge insulating concrete <> 2nd liner @ OD
of concrete
!***       Add 1st radius element to contact of 1st liner <> ins
conc
!***       Add contact 2nd liner <> slab concrete
!***    Correct node select for type,61 real,70   6/9/04
!***    Reorient Beam188 on z=/= 0 face
!***    Fix Liner-Dome common nodes   5/6/04
!***    Delete "j-bolts" in wall    5/6/04
!***    Move j-bolt real definition to pnnla6.mac  3/30/04
!***    Changed Liner Coupling per J. Deibler 3/29/04
!!***   Augmented stiffness 15000   3/24/04
!***    Default convergence criteria  3/22/04
!***    Best estimate soil properties  3/19/04
!***    Soil-Concrete - 5 regions  2/23/04
!***    Correct Drucker-Prager - soil
!***    Correct mat,1 temperature dependent modulus
!***    Replace shell64 with shell181
!***    Primary tank pressure -12" H2O (was -6)
!***    125 pcf overburden, 110 pcf undisturbed soil
!***    10/30/03
```

```
!***    Define additional soils for load factor restart
!***    No cracking insulating concrete
!***    fix mpch (esel,r,mat,,2)
!***    1 yr + 15 day creep  5/14/03
!***   Load step 5 creep for 330 days
!***    New load step 6 => mpch +5 days
!***      "sets" degraded concrete properties
!***
!***   Turn off concrete crushing 5/5/03
!***
!*** Run 2, Load Step 1, 2 & thermal
!***   (8.3' soil, 125 lb/ft3)
!***   (0.06" primary tank corrosion wall, floor)
!*** 4/16/03
!***
!***
!*** JED mods 3/29/03
!***

i_rebuild=1
*if,i_rebuild,eq,1,then
    pnnla
    pnnla2
    pnnla3
    pnnla4
    pnnla5
    pnnla6
    pnnla7
    pnnla8
    pnnla9
*else
    resume,pnnla9,db
*endif

/prep7

allsel
cpdele,all,all

!get misc area components for applying loads, etc.
/input,set_areas_slice,mac

!add steel plate below wall (on slab)
r,45,1/4
csys,22
vsel,s,mat,,2
aslv
asel,r,loc,z,-8.125
asel,r,loc,x,480,498
aatt,1,45,22
mat,1
real,45
amesh,all

!define contact elements (all have default friction of 0.3)
et,60,170
et,61,173
mp,mu,61,.3              !Soil-concrete dome
,mu,62,.4
,mu,63,.01        !4/8/08
,mu,64,.4
,mu,65,.3
```

```
,mu,66,.2
,mu,67,.05       !soil-concrete wall
,mu,68,.3        !soil-concrete footing/top
,mu,69,.05       !soil-concrete footing/side
,mu,70,.6        !soil-concrete foundation
,mu,71,.4        !2nd liner-insulating concrete 6/10/04

!soil_concrete contact - dome
r,61,,,1,.1
real,61
type,61
mat,61
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,z,452,600
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,452,600
esln
esurf

!soil_concrete contact - wall
r,67,,,1,.1
real,67
type,61
mat,67
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,z,-3,453
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,-3,453
esln
esurf

!soil_concrete contact - Footing - top
r,68,,,1,.1
real,68
type,61
mat,68
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,z,-7,-6
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,-7,-6
,r,loc,x,496,530
esln
esurf

!soil_concrete contact - Footing - side
r,69,,,1,.1
real,69
```

E.113

```
type,61
mat,69
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,x,531
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,x,531
esln
esurf

!soil_concrete contact - Foundation
r,70,,,1,.1
real,70
type,61
mat,70
cmsel,s,aconc_soil
nsla,,1
nsel,r,loc,z,-31,-30
,r,loc,x,440,531
cm,foundconc,node
nsla,,1
nsel,r,loc,x,,440
,r,loc,z,-33,-8             !** was -32  6/9/04
cmse,a,foundconc
esln
esurf
type,60
cmsel,s,asoil
nsla,,1
nsel,r,loc,z,-31,-30
,r,loc,x,440,531
cm,foundsoil,node
nsla,,1
nsel,r,loc,x,,440
,r,loc,z,-33,-8
cmse,a,foundsoil
esln
esurf

!secondary liner contact
r,62,,,1,.1
real,62
type,60
mat,62
cmsel,s,aconc_shell
csys,0
asel,u,loc,y,459,99999
nsla,,1
esln
esel,r,mat,,2
esurf
type,61
cmsel,s,area_secon
csys,0
asel,u,loc,y,-99999,3.87
nsla,,1
esln
esurf
```

```
!primary liner contact with dome
r,63,,,1,.1
real,63
type,60
mat,63
cmsel,s,aconc_shell
asel,r,loc,y,450,999        !* 4/8/08
nsla,,1
esln
esel,r,mat,,2
esurf
type,61
cmsel,s,area_prim
asel,r,loc,y,440,999        !* 4/8/08
nsla,,1
esln
esurf

!primary liner contact with insulating concrete
r,64,,,1,.1
real,64
type,60
mat,64
cmsel,s,area_insul_top
nsla,,1
esln
esel,r,mat,,4
esurf
type,61
cmsel,s,area_prim
csys,0
asel,r,loc,y,0
nsla,,1
esln
nsle      !*6/10/04
esurf

!secondary liner contact with foundation concrete  6/10/04
r,71,,,1,.1
real,71
type,60
mat,71
cmse,,slab_top
asel,r,loc,x,-480,-440
nsla,,1
esln
esur
type,61
cmse,,area_secon
asel,r,loc,x,-470,-440
,r,loc,y,-9,-8
nsla,,1
esln
nsle
esur

!merge insulating concrete bottom nodes and secondary liner
nodes
cmsel,s,area_insul_bot
cmsel,a,area_secon
csys,0
```

```
asel,u,loc,y,20,9999
nsla,,1
cpintf,uz,.1

!slab top/insulating concrete
r,65,,,1,.1
real,65
type,60
mat,65
cmsel,s,slab_top
nsla,,1
esln
esurf
type,61
cmsel,s,area_insul_bot
nsla,,1
esln
esurf

!wall/slab contact
r,66,,,1,.1
real,66
type,60
mat,66
asel,,,,986,992
cm,slab_top_wall,area
nsla,,1
esln
esel,r,mat,,2
esurf
type,61
asel,,,,214
,a,,,706
,a,,,913,918,5
,a,,,934
cm,wall_bot,area
nsla,,1
esln
esel,r,mat,,2
esurf

allsel
!esel,s,type,,60
!nsle
!nummrg,node
!nummrg,elem
!esel,s,type,,61
!nsle
!nummrg,elem

max_mat=100
max_real=1000

!define the local coordinate systems and rebar orientations
/input,set_esys_3d,mac

!apply loads
/input,apply_loads_slice,mac
allsel

!apply axisymmetric boundary conditions
csys,22
```

```
nsel,s,loc,y,180
nsel,a,loc,y,180+swp_th-.001,183
csys,0
nsel,a,loc,x,0
d,all,uy,0
d,all,rotx,0
d,all,rotz,0
allsel

nsel,s,loc,x,0
d,all,roty,0

!merge liner/concrete nodes at dome centerline
ksel,s,,,2
ksel,a,,,329
nslk
nummrg,node
allsel

!copy jbolts, etc for slice model
csys,22
esel,s,type,,20,21
cm,e_bolt0,elem
egen,2,500000,all,,,0,0,0,0,0,,swp_th
esel,s,mat,,1
esel,u,real,,45
nsle
nsel,u,,,22789,22790     !*** 5/6/04
,u,,,20260,20261         !*** 6/10/04
nummrg,node

!divide jbolt/bottom anchors properties by 2 for slice model
r,30,.19635/2,.3068e-2/2,.3068e-2/2,.5,.5

esel,s,type,,20,21
cmsel,u,e_bolt0
nsle
nsel,r,,,500000,999999
cm,ntemp,node

vsel,s,mat,,2
vsel,a,mat,,6
csys,0
vsel,u,loc,y,-9999,-8.12
cm,vtemp,volu
*get,nv,volu,,count
*do,i,1,nv
    *get,iv,volu,,num,min
    eslv
    nsle
    cmsel,a,ntemp
    nummrg,node
    cm,ntemp,node
    cmsel,s,vtemp
    vsel,u,,,iv
    cm,vtemp,volu
*enddo

!***
!***  Delete primary-secondary tank coupling at tangent
!***   JED 3/31/03
!***
```

```
r,41,3/16          !insulating concrete confining ring thickness

/prep7

esel,s,mat,,5
nsle,,1
csys,0
*get,top_elev,node,,mxloc,y
cm,soil_elem,elem

*do,i,1,16
   set_slayer,soil_z0(i),soil_z1(i),soil_emod(i),soil_pr(i)
*enddo

max_mat=100
!set backfill/overburden material
*do,i,1,8
   set_backfill,bf_z0(i),bf_z1(i),bf_emod(i),bf_pr
*enddo

!Don't do this!! 5/6/04
!make sure anchors/jbolts/studs etc are merged with concrete
!esel,,type,,12,13
!,a,type,,20,21
!,a,type,,24,25
!nsle
!nsel,u,,,22789,22790    !*** 3/26/04
!numm,node
```

```
!***
!***    Augmented Stiffness  2/27/04
!***
et,32,45
*get,ec350,ex,2,temp,350
mp,ex,12,ec350*0.05              !7/19/04
,prxy,12,.15
esel,,type,,12,15
egen,2,0,all,,,10
esel,,mat,,12
emod,all,type,32

/fil,set_slice_0

!***
!***    Use springs for anchor bolts  8/9/07
!***


alls
csys
et,35,40,,,2                !Anchor bolt axial
,36,40,,,1                  !Anchor bolt shear
*do,i,1,18
r,i,i*24*2*pi/24*swp_th/360*23500/2   !23.5K  -shear  4/17/08
r,80+i,i*24*2*pi/24*swp_th/360*23500/2         !23.5K  -axial
4/17/08
*enddo

csys,11
nsel,,loc,x,480-.5,480+.5
cm,ancb,node
```

```
loca,99,,,,,,,swp_th
csys
*do,i,1,15
cmse,,ancb
csys
nsel,r,loc,z
,r,loc,x,-i*24-1.5,-i*24+1.5
type,35
real,80+i
drot=atan(-nx(ndnext(1))*180/480/(480**2-
nx(ndnext(1))**2)**.5)
loca,50+i,,nx(ndnext(1)),ny(ndnext(1)),,drot
nrot,all
e,ndnext(ndnext(0)),ndnext(0)
type,36
real,i
e,ndnext(0),ndnext(ndnext(0))
*enddo
*do,i,16,18
cmse,,ancb
csys
nsel,r,loc,z
,r,loc,x,-i*24-.5,-i*24+1.5
type,35
real,80+i
drot=atan(-nx(ndnext(1))*180/480/(480**2-
nx(ndnext(1))**2)**.5)
loca,50+i,,nx(ndnext(1)),ny(ndnext(1)),,drot
nrot,all
e,ndnext(ndnext(0)),ndnext(0)
type,36
real,i
e,ndnext(0),ndnext(ndnext(0))
*enddo
*do,i,1,15
cmse,,ancb
csys
nsel,u,loc,z
,r,loc,x,-i*24-1.4,-i*24+1.5
type,35
real,80+i
drot=atan(-nx(ndnext(1))*180/480/(480**2-
nx(ndnext(1))**2)**.5)
csys,99
cloc,70+i,,nx(ndnext(1)),ny(ndnext(1)),,drot
nrot,all
e,ndnext(ndnext(0)),ndnext(0)
type,36
real,i
e,ndnext(0),ndnext(ndnext(0))
*enddo
*do,i,16,18
cmse,,ancb
csys
nsel,u,loc,z
,r,loc,x,-i*24,-i*24+2
type,35
real,80+i
drot=atan(-nx(ndnext(1))*180/480/(480**2-
nx(ndnext(1))**2)**.5)
csys,99
cloc,70+i,,nx(ndnext(1)),ny(ndnext(1)),,drot
```

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```
nrot,all
e,ndnext(ndnext(0)),ndnext(0)
type,36
real,i
e,ndnext(0),ndnext(ndnext(0))
*enddo
!*** Fix BC
esel,,type,,35
nsle
ddel,all,all
d,all,uz
,all,rotx
,all,roty

allsel

!***  2nd liner extension issues   7/21/04
asel,,,,928,,,1
egen,2,100000,all,,,,,4,,,0,0,0
modm,nocheck
alls
emod,15784,-1,114183,104465
,15955,-3,104465,114183
,28878,-3,104465,114183
acle,928
real,62
type,60
mat,62
asel,,,,928,,,1
esln
esel,r,type,,12
esurf
type,61
esel,,type,,23
,r,real,,45
nsle
esurf
dsym,symm,y,5
alls

!***
!***   Temperatures
!***     Uniform 50F  (4/17/03)
!***
tref,80
tunif,80

finish
/filnam,set_slice_0
/sol
!solcontrol,off
neqit,50
time,1
nlgeom,on
nrop,unsym
cnvt,f,,.005,0                  !6/16/04
,m,,.005,0          !6/16/04
crpl,.05
nsub,10,100,5
!delt,.1,.01,.2
!outres,all,all
!nrre,on,250
```

```
eqsl,sparse,.05,-1
bcso,mmd
allsel
save
solve

time,2
!***
!***  Add waste and pressure loads
!***
pres_surf=0              !ground surface uniform pressure psf
point_cent=0             !point load at center lb
pres_annulus=-20         !annulus pressure inches h2o
pres_int=-12             !annulus internal pressure inches h2o
hwaste=35.17*12                 !total waste height
height_waste1=hwaste/3          !height of waste 1 inches
gamma_waste1=1.7                !specific gravity of waste 1
height_waste2=hwaste/3          !height of waste 2 inches
gamma_waste2=1.7                !specific gravity of waste 2
height_waste3=hwaste/3          !height of waste 3 inches
gamma_waste3=1.7                !specific gravity of waste 3

/inp,apply_loads_slice,mac

delt,.1,.01,.25
solv

time,3
!***
!***  Add surface loads
!***
pres_surf=40             !ground surface uniform pressure psf
point_cent=200000        !point load at center lb
pres_annulus=-20         !annulus pressure inches h2o
pres_int=-12             !annulus internal pressure inches h2o
hwaste=35.17*12                 !total waste height
height_waste1=hwaste/3          !height of waste 1 inches
gamma_waste1=1.7                !specific gravity of waste 1
height_waste2=hwaste/3          !height of waste 2 inches
gamma_waste2=1.7                !specific gravity of waste 2
height_waste3=hwaste/3          !height of waste 3 inches
gamma_waste3=1.7                !specific gravity of waste 3

/inp,apply_loads_slice,mac

save
solv
```

Input file: set_parms.mac (Best estimate soil)

```
!***
!***  Best estimate soil properties  3/19/04
!***
!*** Run 2, Load Case 1 - 4
!***   (8.3' soil, 125 lb/ft3)
!***   (0.06" primary tank corrosion)
!*** 4/16/03
!***
!***
!***  JED mods 3/20/03
!***  add clr - concentrated load radius
!***  add backfill properties 3/24
!***  backfill properties f(depth)  4/1
```

```
finish
/clear
/fil,pnnla
/prep7
/titl,BES-BEC, 47K, 350<>160/135F
!
! DST - AY

pi=acos(-1)

clr=10*12        !Concentrated load radius
or=12*41.5       !Outside radius concrete wall
ir=12*40         !Inside radius concrete wall
ir2=12*37.5      !Radius primary tank
icr=37*12+3      !Radius insulating concrete
h1=0
h2=-8.125
h3=381.5         !Height dome tangent  (31'9-1/2")
h4=h3+70.875     !Height exterior corner  (+ 5'10-7/8" = 37'8-3/8")
h5=h3+15*12      !Height interior center dome
h6=h5+15         !Height exterior center dome

covext=2         !Concrete cover - exterior dome
covint1=4        !Concrete cover - wall
covint2=1.5      !Concrete cover - interior dome

r1=105*12+.25    !Exterior dome radius - center
th1=7+(45+14/60)/60    !Angle at tangent of external radii
r2=74*12+4       !Exterior dome radius - outer
r3=3*12+8.375    !Radius primary tank to dome

! This file sets the values of all parameters that may be changed

! These were originally defined in define_soil_layers.mac:

overburden=8.3*12  !overburden height above dome apex (ft)
subdepth=168*12    !subgrade soil depth (ft)
totalwidth=240*12  !total soil width (radius) from tank centerline to edge (ft)

! These were originally defined in dstay7.mac:

r50=1-.06     !shell thickness (in) (R1 of Figure 11 in RPP-13990)
r51=3/8-.06   !shell thickness (in) (R2,R6,R7,R9 of Figure 11 in RPP-13990)
r52=7/8-.06   !shell thickness (in) (R3 of Figure 11 in RPP-13990)
r53=3/4-.06   !shell thickness (in) (R4 of Figure 11 in RPP-13990)
r54=1/2-.06   !shell thickness (in) (R5,R8 of Figure 11 in RPP-13990)
r55=1/4   !shell thickness (in) (R10 of Figure 11 in RPP-13990)

! This was originally defined in set_esys_3d.mac:

r56=3/8   !shell thickness (in) of secondary liner above 357.5 in

! These were originally defined in set_materials.mac:
```

```
![1]        steel (for liner, jbolts, studs, anchors, bearing plates)
steel_ex=27.7e6             !elastic modulus [psi]
steel_prxy=0.3              !Poisson ratio
steel_alpx=6.38             !thermal expansion coefficient
[microstrain/degree F]
steel_gamma=490             !unit weight [lbf/ft^3]
steel_yield=36000           !yield strength [psi]
steel_tan=0.01              !rebar tangent modulus [% of
elastic modulus]

![2]    structural concrete
conc_ex=3.8e6               !elastic modulus [psi]
conc_prxy=0.15              !Poisson ratio
conc_alpx=3.7               !thermal expansion coefficient
[microstrain/degree F]
conc_gamma=145                      !unit weight [lbf/ft^3]

conc_open=0.1  !shear transfer coefficient for open crack
conc_closed=0.98            !shear transfer coefficient for
closed crack
conc_crush=3000             !uniaxial crushing stress [psi]
conc_crack=0.1*conc_crush   !tensile cracking stress [psi]

![3]        rebar
rebar_ex=29.0e6             !elastic modulus [psi]
rebar_prxy=0.3              !Poisson ratio
rebar_alpx=6.               !thermal expansion coefficient
[microstrain/degree F]
rebar_gamma=490             !unit weight [lbf/ft^3]
rebar_yield=71000           !yield strength [psi]
rebar_tan=0                 !rebar tangent modulus [psi]

![4]    insulating concrete
insul_ex=165e3              !elastic modulus [psi]
insul_prxy=0.15             !Poisson ratio
insul_alpx=3.7              !thermal expansion coefficient
[me/F]
insul_gamma=50              !unit weight [lbf/ft^3]

insul_open=0.1              !shear transfer coefficient for
open crack
insul_closed=0.98           !shear transfer coefficient for
closed crack
insul_crush=200             !uniaxial crushing stress [psi]
insul_crack=20              !tensile cracking stress [psi]

![6]        slab rebar
srebar_ex=29.0e6            !elastic modulus [psi]
srebar_prxy=0.3             !Poisson ratio
srebar_alpx=6.              !thermal expansion coefficient
[microstrain/degree F]
srebar_gamma=490            !unit weight [lbf/ft^3]
srebar_yield=49000          !yield strength [psi]
srebar_tan=0                !rebar tangent modulus [psi]

!*** Backfill
! These were originally defined in define_loads.mac:
! [5]       backfill soil
backfill_phi=34.5           !soil friction angle deg
backfill_dil=34.5           !backfill dilatancy angle deg
backfill_cte=0              !thermal expansion coef me/f
```

```
!*** No waste, pressures or ext. load
pres_surf=0              !ground surface uniform pressure psf
point_cent=0             !point load at center lb
pres_annulus=0           !annulus pressure inches h2o
pres_int=0               !annulus internal pressure inches h2o
hwaste=35.17*12                  !total waste height
height_waste1=hwaste/3           !height of waste 1 inches
gamma_waste1=0                   !specific gravity of waste 1
height_waste2=hwaste/3           !height of waste 2 inches
gamma_waste2=0                   !specific gravity of waste 2
height_waste3=hwaste/3           !height of waste 3 inches
gamma_waste3=0                   !specific gravity of waste 3

!define soil layers
*dim,soil_emod,,16
*dim,soil_pr,,16
*dim,soil_z0,,16
*dim,soil_z1,,16
*dim,bf_emod,,8
!*dim,bf_pr,,8
*dim,bf_z0,,8
*dim,bf_z1,,8
bfdinc=(h6+overburden+18.5)/8
sdinc=(subdepth+60)/8

*do,i,1,8
soil_z0(i)=i*bfdinc      !vertical distance from surface
soil_z1(i)=(i-1)*bfdinc
soil_z0(i+8)=i*sdinc+bfdinc*8
soil_z1(i+8)=(i-1)*sdinc+bfdinc*8
bf_z0(i)=i*bfdinc
bf_z1(i)=(i-1)*bfdinc
*enddo

!Elastic modulus
soil_emod(1)=58000,62000,64618,67236,69563,72180,74798,77
125,82117,90000
soil_emod(11)=109697,129650,151456,172835,191000,200000
bf_emod(1)=12000,15000,19500,24000,28000,32500,37000,400
00

!Poisson's ratio
soil_pr(1)=.24,.24,.24,.24,.19,.19,.19,.19,.19,.19
soil_pr(11)=.19,.19,.28,.28,.28,.28
bf_pr=.27

!*** Soil 110 pcf - undisturbed
!*** Soil 125 pcf - backfill/overburden
s_gam=110      !lbf/ft^3 density of soil layers (excluding
backfill)
b_gam=125      !lbf/ft^3 density of soil layers (excluding
backfill)

save
```

Input file: set_parms.mac (Upper bound soil)

```
!***
!***  Upper Bound estimate soil properties  3/21/08
!***
!*** Run 2, Load Case 1 - 4
!***   (8.3' soil, 125 lb/ft3)
!***   (0.06" primary tank corrosion)
```

```
!*** 4/16/03
!***
!***
!*** JED mods 3/20/03
!*** add clr - concentrated load radius
!*** add backfill properties 3/24
!*** backfill properties f(depth) 4/1

finish
/clear
/fil,pnnla
/prep7
/titl,UBS-BEC, 47K, 350<>160/135F
!
! DST - AY

pi=acos(-1)

clr=10*12          !Concentrated load radius
or=12*41.5         !Outside radius concrete wall
ir=12*40           !Inside radius concrete wall
ir2=12*37.5        !Radius primary tank
icr=37*12+3        !Radius insulating concrete
h1=0
h2=-8.125
h3=381.5           !Height dome tangent (31'9-1/2")
h4=h3+70.875       !Height exterior corner (+ 5'10-7/8" =
37'8-3/8")
h5=h3+15*12        !Height interior center dome
h6=h5+15           !Height exterior center dome
covext=2           !Concrete cover - exterior dome
covint1=4          !Concrete cover - wall
covint2=1.5        !Concrete cover - interior dome

r1=105*12+.25      !Exterior dome radius - center
th1=7+(45+14/60)/60   !Angle at tangent of external radii
r2=74*12+4         !Exterior dome radius - outer
r3=3*12+8.375      !Radius primary tank to dome

! This file sets the values of all parameters that may be changed

! These were originally defined in define_soil_layers.mac:

overburden=8.3*12  !overburden height above dome apex (ft)
subdepth=168*12    !subgrade soil depth (ft)
totalwidth=240*12  !total soil width (radius) from tank centerline
to edge (ft)

! These were originally defined in dstay7.mac:

r50=1-.06      !shell thickness (in) (R1 of Figure 11 in RPP-
13990)
r51=3/8-.06    !shell thickness (in) (R2,R6,R7,R9 of Figure 11 in
RPP-13990)
r52=7/8-.06    !shell thickness (in) (R3 of Figure 11 in RPP-
13990)
r53=3/4-.06    !shell thickness (in) (R4 of Figure 11 in RPP-
13990)
r54=1/2-.06    !shell thickness (in) (R5,R8 of Figure 11 in RPP-
13990)
r55=1/4    !shell thickness (in) (R10 of Figure 11 in RPP-13990)
```

! This was originally defined in set_esys_3d.mac:

r56=3/8 !shell thickness (in) of secondary liner above 357.5 in

! These were originally defined in set_materials.mac:

![1] steel (for liner, jbolts, studs, anchors, bearing plates)
steel_ex=27.7e6 !elastic modulus [psi]
steel_prxy=0.3 !Poisson ratio
steel_alpx=6.38 !thermal expansion coefficient [microstrain/degree F]
steel_gamma=490 !unit weight [lbf/ft^3]
steel_yield=36000 !yield strength [psi]
steel_tan=0.01 !rebar tangent modulus [% of elastic modulus]

![2] structural concrete
conc_ex=3.8e6 !elastic modulus [psi]
conc_prxy=0.15 !Poisson ratio
conc_alpx=3.7 !thermal expansion coefficient [microstrain/degree F]
conc_gamma=145 !unit weight [lbf/ft^3]

conc_open=0.1 !shear transfer coefficient for open crack
conc_closed=0.98 !shear transfer coefficient for closed crack
conc_crush=3000 !uniaxial crushing stress [psi]
conc_crack=0.1*conc_crush !tensile cracking stress [psi]

![3] rebar
rebar_ex=29.0e6 !elastic modulus [psi]
rebar_prxy=0.3 !Poisson ratio
rebar_alpx=6. !thermal expansion coefficient [microstrain/degree F]
rebar_gamma=490 !unit weight [lbf/ft^3]
rebar_yield=71000 !yield strength [psi]
rebar_tan=0 !rebar tangent modulus [psi]

![4] insulating concrete
insul_ex=165e3 !elastic modulus [psi]
insul_prxy=0.15 !Poisson ratio
insul_alpx=3.7 !thermal expansion coefficient [me/F]
insul_gamma=50 !unit weight [lbf/ft^3]

insul_open=0.1 !shear transfer coefficient for open crack
insul_closed=0.98 !shear transfer coefficient for closed crack
insul_crush=200 !uniaxial crushing stress [psi]
insul_crack=20 !tensile cracking stress [psi]

![6] slab rebar
srebar_ex=29.0e6 !elastic modulus [psi]
srebar_prxy=0.3 !Poisson ratio
srebar_alpx=6. !thermal expansion coefficient [microstrain/degree F]
srebar_gamma=490 !unit weight [lbf/ft^3]
srebar_yield=49000 !yield strength [psi]
srebar_tan=0 !rebar tangent modulus [psi]

```
!*** Backfill
! These were originally defined in define_loads.mac:
! [5]           backfill soil
backfill_phi=34.5               !soil friction angle deg
backfill_dil=34.5               !backfill dilatancy angle deg
backfill_cte=0                  !thermal expansion coef me/f

!*** No waste, pressures or ext. load
pres_surf=0             !ground surface uniform pressure psf
point_cent=0            !point load at center lb
pres_annulus=0          !annulus pressure inches h2o
pres_int=0              !annulus internal pressure inches h2o
hwaste=35.17*12                 !total waste height
height_waste1=hwaste/3          !height of waste 1 inches
gamma_waste1=0                  !specific gravity of waste 1
height_waste2=hwaste/3          !height of waste 2 inches
gamma_waste2=0                  !specific gravity of waste 2
height_waste3=hwaste/3          !height of waste 3 inches
gamma_waste3=0                  !specific gravity of waste 3

!define soil layers
*dim,soil_emod,,16
*dim,soil_pr,,16
*dim,soil_z0,,16
*dim,soil_z1,,16
*dim,bf_emod,,8
!*dim,bf_pr,,8
*dim,bf_z0,,8
*dim,bf_z1,,8
bfdinc=(h6+overburden+18.5)/8
sdinc=(subdepth+60)/8
*do,i,1,8
soil_z0(i)=i*bfdinc       !vertical distance from surface
soil_z1(i)=(i-1)*bfdinc
soil_z0(i+8)=i*sdinc+bfdinc*8
soil_z1(i+8)=(i-1)*sdinc+bfdinc*8
bf_z0(i)=i*bfdinc
bf_z1(i)=(i-1)*bfdinc
*enddo

!Elastic modulus
soil_emod(1)=75000,78000,80524,83049,85292,87817,90341,92
585,97398,105000
soil_emod(11)=140494,176448,215742,254268,287000,315000
bf_emod(1)=16000,20000,26136,32273,37727,43864,50000,540
00

!Poisson's ratio
soil_pr(1)=.24,.24,.24,.24,.19,.19,.19,.19,.19,.19
soil_pr(11)=.19,.19,.28,.28,.28,.28
bf_pr=.27

!*** Soil 110 pcf - undisturbed
!*** Soil 125 pcf - backfill/overburden
s_gam=110               !lbf/ft^3 density of soil layers (excluding
backfill)
b_gam=125               !lbf/ft^3 density of soil layers (excluding
backfill)

save
```

Input file: set_parms.mac (Lower bound soil)

```
!***
!***  Lower Bound estimate soil properties  3/24/08
!***
!*** Run 2, Load Case 1 - 4
!***   (8.3' soil, 125 lb/ft3)
!***   (0.06" primary tank corrosion)
!*** 4/16/03
!***
!***
!***  JED mods 3/20/03
!***  add clr - concentrated load radius
!***  add backfill properties 3/24
!***  backfill properties f(depth)  4/1

finish
/clear
/fil,pnnla
/prep7
/titl,LBS-BEC, 47K, 350<>160/135F
!
! DST - AY

pi=acos(-1)

clr=10*12         !Concentrated load radius
or=12*41.5            !Outside radius concrete wall
ir=12*40             !Inside radius concrete wall
ir2=12*37.5           !Radius primary tank
icr=37*12+3                !Radius insulating concrete
h1=0
h2=-8.125
h3=381.5             !Height dome tangent  (31'9-1/2")
h4=h3+70.875            !Height exterior corner  (+ 5'10-7/8" =
37'8-3/8")
h5=h3+15*12             !Height interior center dome
h6=h5+15               !Height exterior center dome

covext=2              !Concrete cover - exterior dome
covint1=4             !Concrete cover - wall
covint2=1.5            !Concrete cover - interior dome

r1=105*12+.25           !Exterior dome radius - center
th1=7+(45+14/60)/60      !Angle at tangent of external radii
r2=74*12+4             !Exterior dome radius - outer
r3=3*12+8.375           !Radius primary tank to dome

! This file sets the values of all parameters that may be changed

! These were originally defined in define_soil_layers.mac:

overburden=8.3*12  !overburden height above dome apex (ft)
subdepth=168*12    !subgrade soil depth (ft)
totalwidth=240*12  !total soil width (radius) from tank centerline
to edge (ft)

! These were originally defined in dstay7.mac:

r50=1-.06      !shell thickness (in) (R1 of Figure 11 in RPP-
13990)
r51=3/8-.06     !shell thickness (in) (R2,R6,R7,R9 of Figure 11 in
RPP-13990)
```

r52=7/8-.06 !shell thickness (in) (R3 of Figure 11 in RPP-13990)
r53=3/4-.06 !shell thickness (in) (R4 of Figure 11 in RPP-13990)
r54=1/2-.06 !shell thickness (in) (R5,R8 of Figure 11 in RPP-13990)
r55=1/4 !shell thickness (in) (R10 of Figure 11 in RPP-13990)

! This was originally defined in set_esys_3d.mac:

r56=3/8 !shell thickness (in) of secondary liner above 357.5 in

! These were originally defined in set_materials.mac:

![1] steel (for liner, jbolts, studs, anchors, bearing plates)
steel_ex=27.7e6 !elastic modulus [psi]
steel_prxy=0.3 !Poisson ratio
steel_alpx=6.38 !thermal expansion coefficient [microstrain/degree F]
steel_gamma=490 !unit weight [lbf/ft^3]
steel_yield=36000 !yield strength [psi]
steel_tan=0.01 !rebar tangent modulus [% of elastic modulus]

![2] structural concrete
conc_ex=3.8e6 !elastic modulus [psi]
conc_prxy=0.15 !Poisson ratio
conc_alpx=3.7 !thermal expansion coefficient [microstrain/degree F]
conc_gamma=145 !unit weight [lbf/ft^3]
conc_open=0.1 !shear transfer coefficient for open crack
conc_closed=0.98 !shear transfer coefficient for closed crack
conc_crush=3000 !uniaxial crushing stress [psi]
conc_crack=0.1*conc_crush !tensile cracking stress [psi]

![3] rebar
rebar_ex=29.0e6 !elastic modulus [psi]
rebar_prxy=0.3 !Poisson ratio
rebar_alpx=6. !thermal expansion coefficient [microstrain/degree F]
rebar_gamma=490 !unit weight [lbf/ft^3]
rebar_yield=71000 !yield strength [psi]
rebar_tan=0 !rebar tangent modulus [psi]

![4] insulating concrete
insul_ex=165e3 !elastic modulus [psi]
insul_prxy=0.15 !Poisson ratio
insul_alpx=3.7 !thermal expansion coefficient [me/F]
insul_gamma=50 !unit weight [lbf/ft^3]

insul_open=0.1 !shear transfer coefficient for open crack
insul_closed=0.98 !shear transfer coefficient for closed crack
insul_crush=200 !uniaxial crushing stress [psi]
insul_crack=20 !tensile cracking stress [psi]

![6] slab rebar
srebar_ex=29.0e6 !elastic modulus [psi]

```
srebar_prxy=0.3              !Poisson ratio
srebar_alpx=6.               !thermal expansion coefficient
[microstrain/degree F]
srebar_gamma=490             !unit weight [lbf/ft^3]
srebar_yield=49000           !yield strength [psi]
srebar_tan=0                 !rebar tangent modulus [psi]


!*** Backfill
! These were originally defined in define_loads.mac:
! [5]         backfill soil
backfill_phi=34.5            !soil friction angle deg
backfill_dil=34.5            !backfill dilatancy angle deg
backfill_cte=0               !thermal expansion coef me/f

!*** No waste, pressures or ext. load
pres_surf=0              !ground surface uniform pressure psf
point_cent=0             !point load at center lb
pres_annulus=0           !annulus pressure inches h2o
pres_int=0               !annulus internal pressure inches h2o
hwaste=35.17*12              !total waste height
height_waste1=hwaste/3       !height of waste 1 inches
gamma_waste1=0               !specific gravity of waste 1
height_waste2=hwaste/3       !height of waste 2 inches
gamma_waste2=0               !specific gravity of waste 2
height_waste3=hwaste/3       !height of waste 3 inches
gamma_waste3=0               !specific gravity of waste 3

!define soil layers
*dim,soil_emod,,16
*dim,soil_pr,,16
*dim,soil_z0,,16
*dim,soil_z1,,16
*dim,bf_emod,,8
!*dim,bf_pr,,8
*dim,bf_z0,,8
*dim,bf_z1,,8
bfdinc=(h6+overburden+18.5)/8
sdinc=(subdepth+60)/8

*do,i,1,8
soil_z0(i)=i*bfdinc       !vertical distance from surface
soil_z1(i)=(i-1)*bfdinc
soil_z0(i+8)=i*sdinc+bfdinc*8
soil_z1(i+8)=(i-1)*sdinc+bfdinc*8
bf_z0(i)=i*bfdinc
bf_z1(i)=(i-1)*bfdinc
*enddo

!Elastic modulus
soil_emod(1)=44000,46000,48711,51423,53833,56544,59255,61
665,66835,75000
soil_emod(11)=78900,82851,87169,91403,95000,99000
bf_emod(1)=8000,10000,12864,15727,18273,21136,24000,2600
0

!Poisson's ratio
soil_pr(1)=.24,.24,.24,.24,.19,.19,.19,.19,.19,.19
soil_pr(11)=.19,.19,.28,.28,.28,.28
bf_pr=.27

!*** Soil 110 pcf - undisturbed
```

```
!*** Soil 125 pcf - backfill/overburden
s_gam=110              !lbf/ft^3 density of soil layers (excluding
backfill)
b_gam=125              !lbf/ft^3 density of soil layers (excluding
backfill)

save
```

E.4.2 Thermal Cycling Files

Input file: set_sliceb.inp

```
!***
!***    Use nsub          6/24/04
!***    Adjust mpch (new SS temps) & Day 48 Steady State
6/8/04
!***    Adjust substeps 6/7/04
!***    2 year thermal cycle  ****inp modified****5/19/04
!***   multiple heating and cooling load steps
!***

/fil,set_slice_0
resu

/sol
anty,,rest

!*** Thermal load - Initial ramp
!***
fhrt=7.5/24
time,3+fhrt       !LS 4
!***
!***  Fast heat to 125F
!***
/nopr
/inp,ayfr1,temp
/inp,aybk1,temp
/gopr
nsub,3,10,2
solv

time,6+fhrt       !LS 5
!***
!***  First of four steps to 350F
!***
/nopr
/inp,ayfr2,temp
/inp,aybk2,temp
/gopr
nsub,20,100,6
solv

time,9+fhrt       !LS 6
!***
!***  Second of four steps to 350F
!***
/nopr
/inp,ayfr3,temp
/inp,aybk3,temp
/gopr
nsub,20,100,6
```

```
solv

time,12+fhrt              !LS 7
!***
!*** Third of four steps to 350F
!***
/nopr
/inp,ayfr4,temp
/inp,aybk4,temp
/gopr
nsub,20,100,6
solv

time,14.25+fhrt           !LS 8
!***
!*** Four of four steps to 350F
!***
/nopr
/inp,ayfr5,temp
/inp,aybk5,temp
/gopr
nsub,20,100,6
solv

time,33           !LS 9
!*** 350F
/nopr
/inp,ayfr6,temp
/inp,aybk6,temp
/gopr
nsub,150,1000,10
solv

time,48           !LS 10
!*** Steady state @ 350F
/nopr
/inp,ayfr7,temp
/inp,aybk7,temp
/gopr
nsub,150,1000,15
solv

time,353          !LS 11
!*** Hold for 1 Year
nsub,300,10000,10
solv

time,353+1        !LS 12
!*** mpchg and 1.0 days
*do,i,1,14
esel,,type,,12,15
nsle
nsel,r,bf,temp,190+i*10,200+i*10
esln
esel,r,mat,,2
mpch,20+i,all
*enddo
esel,,type,,12,15
nsle
nsel,r,bf,temp,330,345
esln
esel,r,mat,,2
```

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```
mpch,35,all
esel,all
nsel,all
nsub,10,100,2
solv


time,357          !LS 13
!*** Cool to ambient
!***
!*** First of four steps to 125F
!***
/nopr
/inp,ayfr8,temp
/inp,aybk8,temp
/gopr
nsub,15,200,5
solv

time,360          !LS 14
!***
!*** Second of four steps to 125F
!***
/nopr
/inp,ayfr9,temp
/inp,aybk9,temp
/gopr
nsub,15,200,5
solv

time,363          !LS 15
!***
!*** Third of four steps to 125F
!***
/nopr
/inp,ayfr10,temp
/inp,aybk10,temp
/gopr
nsub,15,200,5
solv

time,365.25       !LS 16
!***
!*** Four of four steps to 125F
!***
/nopr
/inp,ayfr11,temp
/inp,aybk11,temp
/gopr
nsub,15,200,5
solv

time,365.5625           !LS 17
!***
!*** Fast cool down to 80F
!***
/nopr
/inp,ayfr12,temp
/inp,aybk12,temp
/gopr
nsub,7,100,3
solv
```

```
time,366.5625              !LS 18
!***
!*** Tank cool down transient to 80F
!***
/nopr
/inp,ayfr13,temp
/inp,aybk13,temp
/gopr
nsub,5,100,2
solv

time,368           !LS 19
!**** Uniform 80F
nsub,47,150,20
bf,all,temp,80
solv

!*** Cycle once

time,368+fhrt              !LS 20
!***
!*** Thermal load - Initial ramp
!***
/nopr
/inp,ayfr1,temp
/inp,aybk1,temp
/gopr
nsub,3,10,2
solv

time,368+3+fhrt           !LS 21
!***
!*** First of four steps to 350F
!***
/nopr
/inp,ayfr2,temp
/inp,aybk2,temp
/gopr
nsub,20,100,6
solv

time,368+6+fhrt           !LS 22
!***
!*** Second of four steps to 350F
/nopr
/inp,ayfr3,temp
/inp,aybk3,temp
/gopr
nsub,20,100,6
solv

time,368+9+fhrt                    !LS 23
!***
!*** Third of four steps to 350F
!***
/nopr
/inp,ayfr4,temp
/inp,aybk4,temp
/gopr
nsub,20,100,6
solv
```

```
time,368+11.25+fhrt      !LS 24
!***
!***  Four of four steps to 350F
!***
/nopr
/inp,ayfr5,temp
/inp,aybk5,temp
/gopr
nsub,20,100,6
solv

time,368+30              !LS 25
!***
!***  350F
!***
/nopr
/inp,ayfr6,temp
/inp,aybk6,temp
/gopr
nsub,150,1000,10
solv

time,368+45              !LS 26
!***
!***  Steady state @ 350F
!***
/nopr
/inp,ayfr7,temp
/inp,aybk7,temp
/gopr
nsub,150,1000,30
solv

time,368+351             !LS 27
!***
!***  Creep for 1 Year
!***
nsub,300,10000,6
solv

!***  Cool to ambient

time,368+354             !LS 28
!***
!***  First of four steps to 125F
!***
/nopr
/inp,ayfr8,temp
/inp,aybk8,temp
/gopr
nsub,15,200,5
solv

time,368+357             !LS 29
!***
!***  Second of four steps to 125F
!***
/nopr
/inp,ayfr9,temp
/inp,aybk9,temp
/gopr
```

E.135

```
nsub,15,200,5
solv

time,368+360              !LS 30
!***
!***  Third of four steps to 125F
!***
/nopr
/inp,ayfr10,temp
/inp,aybk10,temp
/gopr
nsub,15,200,5
solv

time,368+362.25                    !LS 31
!***
!***  Four of four steps to 125F
!***
/nopr
/inp,ayfr11,temp
/inp,aybk11,temp
/gopr
nsub,15,200,5
solv

time,368+362.5625       !LS 32
!***
!***  Fast cool down to 50F
!***
/nopr
/inp,ayfr12,temp
/inp,aybk12,temp
/gopr
nsub,7,100,3
solv

time,368+363.5625       !LS 33
!***
!***  Tank cool down transient to 80F
!***
/nopr
/inp,ayfr13,temp
/inp,aybk13,temp
/gopr
nsub,5,100,2
solv

time,368+365              !LS 34
!***
!****  Uniform 80F
!***
nsub,47,150,20
bf,all,temp,80
save
solv
```

Input file: set_slicec.inp

```
!***
!***     Use nsub          6/24/04
!***     Adjust mpch (new SS temps) & Day 48 Steady State
6/8/04
!***     Adjust substeps 6/7/04
```

```
!***    2 year thermal cycle  ****inp modified****5/19/04
!***   multiple heating and cooling load steps
!***

/fil,set_slice_0
resu

/sol
anty,,rest

!*** Thermal load - Initial ramp
!***
fhrt=7.5/24

time,3+fhrt        !LS 4
!***
!***  Fast heat to 125F
!***
/nopr
/inp,ayfr1,temp
/inp,aybk1,temp
/gopr
nsub,3,10,2
solv

time,6+fhrt        !LS 5
!***
!***  First of four steps to 350F
!***
/nopr
/inp,ayfr2,temp
/inp,aybk2,temp
/gopr
nsub,20,100,6
solv

time,9+fhrt        !LS 6
!***
!***  Second of four steps to 350F
!***
/nopr
/inp,ayfr3,temp
/inp,aybk3,temp
/gopr
nsub,20,100,6
solv

time,12+fhrt                !LS 7
!***
!***  Third of four steps to 350F
!***
/nopr
/inp,ayfr4,temp
/inp,aybk4,temp
/gopr
nsub,20,100,6
solv

time,14.25+fhrt             !LS 8
!***
!***  Four of four steps to 350F
!***
```

```
/nopr
/inp,ayfr5,temp
/inp,aybk5,temp
/gopr
nsub,20,100,6
solv

time,33           !LS 9
!***  350F
/nopr
/inp,ayfr6,temp
/inp,aybk6,temp
/gopr
nsub,150,1000,10
solv

time,48           !LS 10
!***  Steady state @ 350F
/nopr
/inp,ayfr7,temp
/inp,aybk7,temp
/gopr
nsub,150,1000,15
solv

time,353          !LS 11
!***  Hold for 1 Year
nsub,300,10000,10
solv

time,353+1        !LS 12
!***  mpchg and 1.0 days
*do,i,1,14
esel,,type,,12,15
nsle
nsel,r,bf,temp,190+i*10,200+i*10
esln
esel,r,mat,,2
mpch,20+i,all
*enddo
esel,,type,,12,15
nsle
nsel,r,bf,temp,330,345
esln
esel,r,mat,,2
mpch,35,all
esel,all
nsel,all
nsub,10,100,2
solv

time,357          !LS 13
!***  Cool to ambient
!***
!***  First of four steps to 125F
!***
/nopr
/inp,ayfr8,temp
/inp,aybk8,temp
/gopr
nsub,15,200,5
solv
```

```
time,360          !LS 14
!***
!***  Second of four steps to 125F
!***
/nopr
/inp,ayfr9,temp
/inp,aybk9,temp
/gopr
nsub,15,200,5
solv

time,363          !LS 15
!***
!***  Third of four steps to 125F
!***
/nopr
/inp,ayfr10,temp
/inp,aybk10,temp
/gopr
nsub,15,200,5
solv

time,365.25       !LS 16
!***
!***  Four of four steps to 125F
!***
/nopr
/inp,ayfr11,temp
/inp,aybk11,temp
/gopr
nsub,15,200,5
solv

time,365.5625          !LS 17
!***
!***  Fast cool down to 80F
!***
/nopr
/inp,ayfr12,temp
/inp,aybk12,temp
/gopr
nsub,7,100,3
solv

time,366.5625          !LS 18
!***
!***  Tank cool down transient to 80F
!***
/nopr
/inp,ayfr13,temp
/inp,aybk13,temp
/gopr
nsub,5,100,2
solv

time,368          !LS 19
!****  Uniform 80F
nsub,47,150,20
bf,all,temp,80
solv
```

```
!***  Cycle once

time,368+fhrt            !LS 20
!***
!***  Thermal load - Initial ramp
!***
/nopr
/inp,ayfr1,temp
/inp,aybk1,temp
/gopr
nsub,3,10,2
solv

time,368+3+fhrt          !LS 21
!***
!***  First of four steps to 350F
!***
/nopr
/inp,ayfr2,temp
/inp,aybk2,temp
/gopr
nsub,20,100,6
solv

time,368+6+fhrt          !LS 22
!***
!***  Second of four steps to 350F
/nopr
/inp,ayfr3,temp
/inp,aybk3,temp
/gopr
nsub,20,100,6
solv

time,368+9+fhrt          !LS 23
!***
!***  Third of four steps to 350F
!***
/nopr
/inp,ayfr4,temp
/inp,aybk4,temp
/gopr
nsub,20,100,6
solv

time,368+11.25+fhrt      !LS 24
!***
!***  Four of four steps to 350F
!***
/nopr
/inp,ayfr5,temp
/inp,aybk5,temp
/gopr
nsub,20,100,6
solv

time,368+30              !LS 25
!***
!***  350F
!***
```

```
/nopr
/inp,ayfr6,temp
/inp,aybk6,temp
/gopr
nsub,150,1000,10
solv

time,368+45          !LS 26
!***
!***  Steady state @ 350F
!***
/nopr
/inp,ayfr7,temp
/inp,aybk7,temp
/gopr
nsub,150,1000,30
solv

time,368+351         !LS 27
!***
!***  Creep for 1 Year
!***
nsub,300,10000,6
solv

!***  Cool to ambient

time,368+354         !LS 28
!***
!***  First of four steps to 125F
!***
```

```
/nopr
/inp,ayfr8,temp
/inp,aybk8,temp
/gopr
nsub,15,200,5
solv

time,368+357         !LS 29
!***
!***  Second of four steps to 125F
!***
/nopr
/inp,ayfr9,temp
/inp,aybk9,temp
/gopr
nsub,15,200,5
solv

time,368+360         !LS 30
!***
!***  Third of four steps to 125F
!***
/nopr
/inp,ayfr10,temp
/inp,aybk10,temp
/gopr
nsub,15,200,5
solv

time,368+362.25            !LS 31
!***
```

```
!***  Four of four steps to 125F
!***
/nopr
/inp,ayfr11,temp
/inp,aybk11,temp
/gopr
nsub,15,200,5
solv

time,368+362.5625        !LS 32
!***
!***  Fast cool down to 50F
!***
/nopr
/inp,ayfr12,temp
/inp,aybk12,temp
/gopr
nsub,7,100,3
solv

time,368+363.5625        !LS 33
!***
!***  Tank cool down transient to 80F
!***
/nopr
/inp,ayfr13,temp
/inp,aybk13,temp
/gopr
nsub,5,100,2
solv

time,368+365             !LS 34
!***
!****  Uniform 80F
!***
nsub,47,150,20
bf,all,temp,80
save
solv
```

Input file: set_sliced.inp

```
!***
!***     Use nsub           6/24/04
!***     Adjust mpch (new SS temps) & Day 48 Steady State
6/8/04
!***     Adjust substeps 6/7/04
!***     2 year thermal cycle  ****inp modified****5/19/04
!***    multiple heating and cooling load steps
!***

/fil,set_slice_0
resu

/sol
anty,,rest

!*** Thermal load - Initial ramp
!***
fhrt=7.5/24

time,3+fhrt+365*20                 !LS 4
!***
```

```
!***  Fast heat to 125F
!***
/nopr
/inp,ayfr1,temp
/inp,aybk1,temp
/gopr
nsub,3,10,2
solv

time,6+fhrt+365*20               !LS 5
!***
!***  First of four steps to 160F
!***
/nopr
/inp,ayfr2,temp
/inp,aybk2,temp
/gopr
nsub,20,100,6
solv

time,9+fhrt+365*20               !LS 6
!***
!***  Second of four steps to 160F
!***
/nopr
/inp,ayfr3,temp
/inp,aybk3,temp
/gopr
nsub,20,100,6
solv

time,12+fhrt+365*20              !LS 7
!***
!***  Third of four steps to 160F
!***
/nopr
/inp,ayfr4,temp
/inp,aybk4,temp
/gopr
nsub,20,100,6
solv

time,15+fhrt+365*20              !LS 8
!***
!***  Four of four steps to 160F
!***
/nopr
/inp,ayfr5,temp
/inp,aybk5,temp
/gopr
nsub,20,100,6
solv

time,30+365*20                   !LS 9
!***  Steady state @ 160F
/nopr
/inp,ayfr6,temp
/inp,aybk6,temp
/gopr
nsub,20,1000,10
solv
```

```
time,353+365*20          !LS 11
!***  Hold for 1 Year
nsub,30,10000,10
solv

time,357+365*20          !LS 13
!***  Cool to ambient
!***
!***  First steps to 125F
!***
/nopr
/inp,ayfr7,temp
/inp,aybk7,temp
/gopr
nsub,15,200,5
solv

time,360+365*20          !LS 14
!***
!***  First step to 80F
!***
/nopr
/inp,ayfr8,temp
/inp,aybk8,temp
/gopr
nsub,15,200,5
solv

time,363+365*20          !LS 15
!***
!***  Second step to 80F
!***
/nopr
/inp,ayfr9,temp
/inp,aybk9,temp
/gopr
nsub,15,200,5
solv

time,365+365*20          !LS 16
!***
!***  Third step to 80F
!***
/nopr
/inp,ayfr10,temp
/inp,aybk10,temp
/gopr
nsub,15,200,5
solv

time,367+365*20          !LS 17
!***
!***  Third step to 80F
!***
/nopr
/inp,ayfr11,temp
/inp,aybk11,temp
/gopr
nsub,15,200,5
solv

time,368+365*20          !LS 18
```

```
!**** Uniform 80F
nsub,15,150,10
bf,all,temp,80
solv

!*** Cycle once

time,3+fhrt+365*21                !LS 19
!***
!*** Thermal load - Initial ramp
!***
/nopr
/inp,ayfr1,temp
/inp,aybk1,temp
/gopr
nsub,3,10,2
solv

time,6+fhrt+365*21                !LS 20
!***
!*** First of four steps to 195F
!***
/nopr
/inp,ayfr2,temp
/inp,aybk2,temp
/gopr
nsub,20,100,6
solv

time,9+fhrt+365*21                !LS 21
!***
!*** Second of four steps to 195F
/nopr
/inp,ayfr3,temp
/inp,aybk3,temp
/gopr
nsub,20,100,6
solv

time,12+fhrt+365*21     !LS 22
!***
!*** Third of four steps to 195F
!***
/nopr
/inp,ayfr4,temp
/inp,aybk4,temp
/gopr
nsub,20,100,6
solv

time,15+fhrt+365*21     !LS 23
!***
!*** Four of four steps to 195F
!***
/nopr
/inp,ayfr5,temp
/inp,aybk5,temp
/gopr
nsub,20,100,6
solv

time,30+365*21                    !LS 24
```

```
!***
!***  195F
!***
/nopr
/inp,ayfr6,temp
/inp,aybk6,temp
/gopr
nsub,20,1000,10
solv

time,354+365*21          !LS 26
!***
!***  Creep for 1 Year
!***
nsub,30,1000,10
solv

!***  Cool to ambient

time,357+365*21          !LS 27
!***
!***  First step to 125F
!***
/nopr
/inp,ayfr7,temp
/inp,aybk7,temp
/gopr
nsub,15,200,5
solv

time,360+365*21          !LS 28
!***
!***  First step to 80F
!***
/nopr
/inp,ayfr8,temp
/inp,aybk8,temp
/gopr
nsub,15,200,5
solv

time,363+365*21          !LS 29
!***
!***  Second step to 80F
!***
/nopr
/inp,ayfr9,temp
/inp,aybk9,temp
/gopr
nsub,15,200,5
solv

time,365+365*21          !LS 30
!***
!***  Third step to 80F
!***
/nopr
/inp,ayfr10,temp
/inp,aybk10,temp
/gopr
nsub,15,200,5
solv
```

```
time,367+365*21                 !LS 31
!***
!***  Third step to 80F
!***
/nopr
/inp,ayfr11,temp
/inp,aybk11,temp
/gopr
nsub,15,200,5
solv

time,368+365*21                 !LS 32
!***
!****  Uniform 80F
!***
nsub,15,150,10
bf,all,temp,80
save
solv
```


Input file: set_slicee.inp

```
!***
!***     Years 23 - 58     3/13/08
!***     2 year thermal cycle  ****inp modified****5/19/04
!***    multiple heating and cooling load steps
!***

/fil,set_slice_0
resu
/sol
anty,,rest

!*** Thermal load - Initial ramp
!***
fhrt=7.5/24

time,3+fhrt+365*22
!***
!***  Fast heat to 125F
!***
/nopr
/inp,ayfr1,temp
/inp,aybk1,temp
/gopr
nsub,6,20,2
solv

time,6+fhrt+365*22
!***
!***  First of four steps to 250F
!***
/nopr
/inp,ayfr2,temp
/inp,aybk2,temp
/gopr
nsub,20,100,6
solv

time,9+fhrt+365*22
!***
```

E.147

```
!*** Second of four steps to 250F
!***
/nopr
/inp,ayfr3,temp
/inp,aybk3,temp
/gopr
nsub,20,100,6
solv

time,12+fhrt+365*22
!***
!*** Third of four steps to 250F
!***
/nopr
/inp,ayfr4,temp
/inp,aybk4,temp
/gopr
nsub,20,100,6
solv

time,15+fhrt+365*22
!***
!*** Four of four steps to 250F
!***
/nopr
/inp,ayfr5,temp
/inp,aybk5,temp
/gopr
nsub,22,200,10
solv

time,25+365*22
!*** 250F
/nopr
/inp,ayfr6,temp
/inp,aybk6,temp
/gopr
nsub,180,2000,20
solv

!*** Hold for 36 Year

time,354+365*57
nsub,300,10000,30
solv

!*** Cool to ambient

time,357+365*57
!***
!*** First of four steps to 125F
!***
/nopr
/inp,ayfr7,temp
/inp,aybk7,temp
/gopr
nsub,15,200,5
solv

time,360+365*57
!***
!*** Second of four steps to 125F
```

E.148

```
!***
/nopr
/inp,ayfr8,temp
/inp,aybk8,temp
/gopr
nsub,15,200,5
solv

time,363+365*57
!***
!***  Third of four steps to 125F
!***
/nopr
/inp,ayfr9,temp
/inp,aybk9,temp
/gopr
nsub,15,200,5
solv

time,365+365*57
!***
!***  Four of four steps to 125F
!***
/nopr
/inp,ayfr10,temp
/inp,aybk10,temp
/gopr
nsub,15,200,5
solv

time,367+365*57
!***
!***  Fast cool down to 80F
!***
/nopr
/inp,ayfr11,temp
/inp,aybk11,temp
/gopr
nsub,10,100,5
solv

time,368+365*57
!****  Uniform 80F
nsub,15,150,10
bf,all,temp,80
save
solv
```

Input file: set_slicef.inp

```
!***
!***     Use nsub          6/24/04
!***     Adjust mpch (new SS temps) & Day 48 Steady State
6/8/04
!***     Adjust substeps 6/7/04
!***     2 year thermal cycle  ****inp modified****5/19/04
!***    multiple heating and cooling load steps
!***

/fil,set_slice_0
resu

/sol
```

```
anty,,rest

!*** Thermal load - Initial ramp
!***
fhrt=7.5/24

time,3+fhrt+365*58                !LS 4
!***
!***  Fast heat to 125F
!***
/nopr
/inp,ayfr1,temp
/inp,aybk1,temp
/gopr
nsub,3,10,2
solv

time,6+fhrt+365*58                !LS 5
!***
!***  First of four steps to 195F
!***
/nopr
/inp,ayfr2,temp
/inp,aybk2,temp
/gopr
nsub,20,100,6
solv

time,9+fhrt+365*58                !LS 6
!***
!***  Second of four steps to 195F
!***
/nopr
/inp,ayfr3,temp
/inp,aybk3,temp
/gopr
nsub,20,100,6
solv

time,12+fhrt+365*58               !LS 7
!***
!***  Third of four steps to 195F
!***
/nopr
/inp,ayfr4,temp
/inp,aybk4,temp
/gopr
nsub,20,100,6
solv

time,15+fhrt+365*58               !LS 8
!***
!***  Four of four steps to 195F
!***
/nopr
/inp,ayfr5,temp
/inp,aybk5,temp
/gopr
nsub,20,100,6
solv

time,30+365*58                         !LS 9
```

```
!***  Steady state @ 195F
/nopr
/inp,ayfr6,temp
/inp,aybk6,temp
/gopr
nsub,20,1000,10
solv

time,353+365*58                !LS 11
!***  Hold for 1 Year
nsub,30,10000,10
solv

time,357+365*58                !LS 13
!***  Cool to ambient
!***
!***  First steps to 125F
!***
/nopr
/inp,ayfr7,temp
/inp,aybk7,temp
/gopr
nsub,15,200,5
solv

time,360+365*58                !LS 14
!***
!***  First step to 80F
!***
/nopr
/inp,ayfr8,temp
/inp,aybk8,temp
/gopr
nsub,15,200,5
solv

time,363+365*58                !LS 15
!***
!***  Second step to 80F
!***
/nopr
/inp,ayfr9,temp
/inp,aybk9,temp
/gopr
nsub,15,200,5
solv

time,365+365*58                !LS 16
!***
!***  Third step to 80F
!***
/nopr
/inp,ayfr10,temp
/inp,aybk10,temp
/gopr
nsub,15,200,5
solv

time,367+365*58                !LS 17
!***
!***  Third step to 80F
!***
```

```
/nopr
/inp,ayfr11,temp
/inp,aybk11,temp
/gopr
nsub,15,200,5
solv

time,368+365*58                    !LS 18
!****  Uniform 80F
nsub,15,150,10
bf,all,temp,80
solv

!***  Cycle once

time,3+fhrt+365*59                 !LS 19
!***
!***  Thermal load - Initial ramp
!***
/nopr
/inp,ayfr1,temp
/inp,aybk1,temp
/gopr
nsub,3,10,2
solv

time,6+fhrt+365*59                 !LS 20
!***
!***  First of four steps to 195F
!***
/nopr
/inp,ayfr2,temp
/inp,aybk2,temp
/gopr
nsub,20,100,6
solv

time,9+fhrt+365*59                 !LS 21
!***
!***  Second of four steps to 195F
/nopr
/inp,ayfr3,temp
/inp,aybk3,temp
/gopr
nsub,20,100,6
solv

time,12+fhrt+365*59     !LS 22
!***
!***  Third of four steps to 195F
!***
/nopr
/inp,ayfr4,temp
/inp,aybk4,temp
/gopr
nsub,20,100,6
solv

time,15+fhrt+365*59     !LS 23
!***
!***  Four of four steps to 195F
!***
```

```
/nopr
/inp,ayfr5,temp
/inp,aybk5,temp
/gopr
nsub,20,100,6
solv

time,30+365*59                !LS 24
!***
!***  195F
!***
/nopr
/inp,ayfr6,temp
/inp,aybk6,temp
/gopr
nsub,20,1000,10
solv

time,354+365*59               !LS 26
!***
!***  Creep for 1 Year
!***
nsub,30,1000,10
solv

!***  Cool to ambient

time,357+365*59               !LS 27
!***
!***  First step to 125F
!***
/nopr
/inp,ayfr7,temp
/inp,aybk7,temp
/gopr
nsub,15,200,5
solv

time,360+365*59               !LS 28
!***
!***  First step to 80F
!***
/nopr
/inp,ayfr8,temp
/inp,aybk8,temp
/gopr
nsub,15,200,5
solv

time,363+365*59               !LS 29
!***
!***  Second step to 80F
!***
/nopr
/inp,ayfr9,temp
/inp,aybk9,temp
/gopr
nsub,15,200,5
solv

time,365+365*59               !LS 30
!***
```

```
!*** Third step to 80F
!***
/nopr
/inp,ayfr10,temp
/inp,aybk10,temp
/gopr
nsub,15,200,5
solv

time,367+365*59                !LS 31
!***
!*** Third step to 80F
!***
/nopr
/inp,ayfr11,temp
/inp,aybk11,temp
/gopr
nsub,15,200,5
solv

time,368+365*59                !LS 32
!***
!**** Uniform 80F
!***
nsub,15,150,10
bf,all,temp,80
save
solv
```

Anchor bolt postprocessing input file

```
! Post-processing shear Forces

set,????

esel,,type,,35,36
nsle
csys,5
etab,fxi,smisc,1
,uxi,nmisc,3
etab,jloc,cent,x
esel,,type,,35          !axial
esor,etab,jloc,1
pret,jloc,uxi,fxi
esel,,type,,36          !shear
esor,etab,jloc,1
pret,jloc,uxi,fxi
```

Appendix F

Software Acceptance

1) Project Title and Number: DST Thermal and Seismic Analyses 48971

2) Software Name and Version: ANSYS 7.0 (Rev. 11)

3) Computer and Property Number: Dell PWS 530 WD39892

4) Operating System: Windows XP Professional Version 2002 Service Pack 2

4) Scope of Testing: Software reinstallation (XP SP2)

5) Tests: Execute ANSYS Verification Testing Package

6) Discrepancies:

   a) c0231. These differences are acceptable per the ANSYS Verification Package User's Guide – ANSYS Release 7.0 (AVPUG).
   b) vm184. These differences occur at the 5th significant figure.
   c) vm198. This difference is the reporting of the customer number for this installation.
   d) vmc8. These differences are acceptable as noted in the output because of the difference in number of iterations and accuracy.
   e) cyc-177s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).
   f) cyc-178s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).
   g) dds-13s. This test case requires the "Parallel Performance Module" which is not part of this software installation and is not required for the DST analyses.
   h) dds-17s. This test case requires the "Parallel Performance Module" which is not part of this software installation and is not required for the DST analyses.
   i) ev173-53s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).
   j) ev175-20s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).
   k) ev175-21s. This test case requires the "Parallel Performance Module" which is not part of this software installation and is not required for the DST analyses.
   l) inrt-16s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).
   m) sx120-1s. This test case requires the "Frequency Sweep Module" which is not part of this software installation and is not required for the DST analyses.

7) Finding: This installation of ANSYS is acceptable

Certified by:

JE Deibler John E Deibler 2/24/05
Code Custodian

Reviewed by:

KI Johnson Kenneth I Johnson 4/16/05
Lead Engineer

12/1 0/2002 Page 1 of 1 Addendum to ANSYS Verification Testing Package User's Guide -ANSYS Release 7.0

Notes for test case cO231

Test case cO231 may show considerable differences for the Phase Angle value that is part of the Post1 Nodal Degree of Freedom Listing (PRNS command) output. Any such differences do not indicate a problem with this test case's results and should be considered acceptable. The output items of significance for this test case are the UZ values in the Post1 Nodal Degree of Freedom Listing. Machine precision differences in the form of small numerical differences that are trivial with respect to the test's output items of significance may also show for this test case in the compare output for this test. Please see **Verifying ANSYS and Evaluating COMPARE Differences** in Chapter 2 of the *ANSYS Verification Testing Package User's Guide* for more information on evaluating COMPARE differences. The following is an example of acceptable COMPARE differences for test case cO231 :

COMPARE DIFFERENCE FOUND AT G= NODAL RESULTS ARE FOR CYCLIC SECTOR T= NODAL RESULTS ARE FOR CYCLIC SECTOR

COMPARE DIFFERENCE FOUND AT G= VALUE -9.8117 -3.7700 22. T= VALUE -9.8119 -3.7693 22.

COMPARE DIFFERENCE FOUND AT G= NODAL RESULTS ARE FOR CYCLIC SECTOR T= NODAL RESULTS ARE FOR CYCLIC SECTOR

COMPARE DIFFERENCE FOUND AT G= VALUE -9.7579 -3.9649 22. T= VALUE -9.7581 -3.9643 22.

COMPARE DIFFERENCE FOUND AT G= NODAL RESULTS ARE FOR CYCLIC SECTOR T= NODAL RESULTS ARE FOR CYCLIC SECTOR

COMPARE DIFFERENCE FOUWAT --~-*c;;;i';;* G= 8 0.53291 0.39425 io T= 8 0.53293 *p.39419* 10

COMPARE DIFFERENCE FOUND AT G= 10 0.52495 0.39568 9. T= 10 0.52497 0.39562 9.

COMPARE DIFFERENCE FOUND AT NG= 259 NT= 259 G= 12 0.50433 0.40282 8.6482 8.6722 T= 12 0.50435 0.40276 8.6471 8.6711

COMPARE DIFFERENCE FOUND AT NG= 260 NT= 260 G= 14 0.48186 0.41201 7.8710 7.8965 T= 14 0.48188 0.41196 7.8700 7.8955

COMPARE DIFFERENCE FOUND AT NG= 261 NT= 261 G= 16 0.45505 0.42478 7.0719 7.0992 T= 16 0.45507 0.42473 7.0710 7.0983

COMPARE DIFFERENCE FOUND AT NG= 262 NT= 262 G= 18 0.42339 0.44092 6.2424 6.2723 T= 18 0.42341 0.44086 6.2417 6.2715

COMPARE DIFFERENCE FOUND AT NG= 263 NT= 263 G= 20 0.38501 0.46124 5.3732 5.4067 T= 20 0.38502 0.46118 5.3726 5.4061

COMPARE DIFFERENCE FOUND AT NG= 267 NT= 267 G= VALUE -9.6034 -3.9649 18.806 21.413 T= VALUE -9.6036 -3.9643 18.805 21.412

NG= 271 NT= 271 22.469 24.766 22.469 24.766

NG= 192 NT= 192 1 -PHASE ANGLE = 1- **PHASE ANGLE** =

NG= 213 NT= 213 469 24.766 469 24.766

NG= 219 NT= 219 2- PHASE ANGLE = 2- **PHASE ANGLE** =

NG= 240 NT= 240 440 24.710 440 24.710

NG= 246 NT= 246 3- PHASE ANGLE = 3 **-PHASE ANGLE** =

NG-= **257** ***m-~-257 .161 10.183 .160 10.181***

NG= 4080 4068

258 NT= 258 9.4309 9.4297

COMPARE DIFFERENCE FOUND **AT G= VALUE -9.8117 -3.9649 T= VALUE -9.8119 -3.9643**

30.580 306.570

30.580 306.570

30.580 306.570

Notes for Test Case vrn212

Test case vm212 may produce an expected compare difference due to an inconsequential warning message that appears in the ANSYS, Inc. supplied output file that may not appear in the output file generated by your system for this test case. This compare difference should be considered acceptable. The following is an example of this compare difference.

```
COMPARE DIFFERENCE FOUND AT          NG= 445 NT= 436
G= NUMBER OF WARNING MESSAGES ENCOUNTERED= 1
T= NUMBER OF WARNING MESSAGES ENCOUNTERED= 0
```

Notes for Test Cases cyc-177s, cyc-178s, ev-173-53s, ev-175-20s, inrt-16s, and inrt-9s

Test cases cyc-177s, cyc-178s, ev-173-53s, ev-175-20s, inrt-16s, and inrt-9s may produce expected compare differences due to the use of a macro named qaend. The method that is used in the verification procudure (runqa) to handle this macro may cause one or more comparison differences. Any such compare differences are inconsequential and should be considered acceptable. The following is an example of such a compare difference.

```
EXTRA DATA SKIPPED ON TEST FILE          NG= 1033 NT= 1030
T= USE COMMAND MACRO qaend
T= ARGS= 137.00
END OF SKIPPED DATA                      NG= 1033 NT= 1033
```

Notes for test Cases dds-13s, dds-17s, and ev175-21 s

The test cases dds-13s, dds-17s, and ev175-21 s will run to completion only if the "Parallel Performance for ANSYS" product (DDS and AMG solvers) is included in your ANSYS installation.

```
c0211r2        7020021010   70SP20030909  0    0   605   605   81%  02/12/2005    11:02 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0212          7020021010   70SP20030909  0    0   223   223   45%  02/12/2005    11:02 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0213          7020021010   70SP20030909  0    0   197   197   41%  02/12/2005    11:02 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0214          7020021010   70SP20030909  0    0   409   409   67%  02/12/2005    11:02 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0215          7020021010   70SP20030909  0    0   648   648   81%  02/12/2005    11:02 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0216          7020021010   70SP20030909  0    0   510   510   74%  02/12/2005    11:02 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0217          7020021010   70SP20030909  0    0   332   332   66%  02/12/2005    11:02 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0218          7020021010   70SP20030909  0    0  1627  1627   93%  02/12/2005    11:02 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0219          7020021010   70SP20030909  0    0  2732  2732   95%  02/12/2005    11:03 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0220          7020021010   70SP20030909  0    0   494   494   76%  02/12/2005    11:03 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0221          7020021010   70SP20030909  0    0  1265  1265   90%  02/12/2005    11:03 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0222          7020021010   70SP20030909  0    0  1543  1543   92%  02/12/2005    11:03 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0223          7020021010   70SP20030909  0    0   362   362   66%  02/12/2005    11:03 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0224          7020021010   70SP20030909  0    0   307   307   59%  02/12/2005    11:04 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0225          7020021010   70SP20030909  0    0   420   420   70%  02/12/2005    11:04 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0226          7020021010   70SP20030909  0    0   521   521   74%  02/12/2005    11:04 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0227          7020021010   70SP20030909  0    0   380   380   65%  02/12/2005    11:04 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0227a         7020021010   70SP20030909  0    0   380   380   65%  02/12/2005    11:04 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0228          7020021010   70SP20030909  0    0   236   236   50%  02/12/2005    11:04 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0229          7020021010   70SP20030909  0    0   715   715   81%  02/12/2005    11:04 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 c0230          7020021010   70SP20030909  0    0  2513  2513   94%  02/12/2005    11:04 INTEL_NT
INTEL_NT       QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
```

```
 c0231             7020021010    70SP20030909   3    0   304   304   61%  02/12/2005    11:05 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0232             7020021010    70SP20030909   0    0   517   517   79%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0233             7020021010    70SP20030909   0    0   542   542   75%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0234             7020021010    70SP20030909   0    0   420   420   68%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm1               7020021010    70SP20030909   0    0   474   474   72%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm2               7020021010    70SP20030909   0    0   667   667   81%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm3               7020021010    70SP20030909   0    0   499   499   73%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm4               7020021010    70SP20030909   0    0   434   434   69%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm5               7020021010    70SP20030909   0    0   884   884   85%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm6               7020021010    70SP20030909   0    0   854   854   83%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm7               7020021010    70SP20030909   0    0  2176  2176   93%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm8               7020021010    70SP20030909   0    0   346   346   64%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm9               7020021010    70SP20030909   0    0   851   851   85%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm10              7020021010    70SP20030909   0    0   437   437   69%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm11              7020021010    70SP20030909   0    0   885   885   85%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm12              7020021010    70SP20030909   0    0   444   444   70%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm13              7020021010    70SP20030909   0    0   464   464   71%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm14              7020021010    70SP20030909   0    0   537   537   76%  02/12/2005    11:06 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm15              7020021010    70SP20030909   0    0  1356  1356   91%  02/12/2005    11:07 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm16              7020021010    70SP20030909   0    0   740   740   82%  02/12/2005    11:07 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm17              7020021010    70SP20030909   0    0   546   546   76%  02/12/2005    11:07 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
```

```
 vm18              7020021010    70SP20030909   0    0   450   450   71%  02/12/2005    11:07 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm19              7020021010    70SP20030909   0    0   725   725   80%  02/12/2005    11:07 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm20              7020021010    70SP20030909   0    0   449   449   70%  02/12/2005    11:07 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm21              7020021010    70SP20030909   0    0   805   805   82%  02/12/2005    11:07 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm22              7020021010    70SP20030909   0    0   398   398   66%  02/12/2005    11:07 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm23              7020021010    70SP20030909   0    0  1043  1043   88%  02/12/2005    11:07 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm24              7020021010    70SP20030909   0    0   766   766   82%  02/12/2005    11:07 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm25              7020021010    70SP20030909   0    0  2350  2350   95%  02/12/2005    11:07 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm26              7020021010    70SP20030909   0    0  1829  1829   89%  02/12/2005    11:08 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm27              7020021010    70SP20030909   0    0   910   910   85%  02/12/2005    11:08 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm28              7020021010    70SP20030909   0    0   418   418   70%  02/12/2005    11:08 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm29              7020021010    70SP20030909   0    0   683   683   80%  02/12/2005    11:08 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm30              7020021010    70SP20030909   0    0   449   449   70%  02/12/2005    11:08 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm31              7020021010    70SP20030909   0    0   551   551   76%  02/12/2005    11:08 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm32              7020021010    70SP20030909   0    0   881   881   84%  02/12/2005    11:08 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm33              7020021010    70SP20030909   0    0   902   902   85%  02/12/2005    11:08 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm34              7020021010    70SP20030909   0    0  1380  1380   90%  02/12/2005    11:08 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm35              7020021010    70SP20030909   0    0   594   594   77%  02/12/2005    11:08 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm36              7020021010    70SP20030909   0    0  1086  1086   88%  02/12/2005    11:08 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm37              7020021010    70SP20030909   0    0   690   690   81%  02/12/2005    11:08 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm38              7020021010    70SP20030909   0    0  1667  1667   92%  02/12/2005    11:08 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm39            7020021010   70SP20030909  0    0   819   819   84%  02/12/2005    11:09 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm40            7020021010   70SP20030909  0    0   876   876   86%  02/12/2005    11:09 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm41            7020021010   70SP20030909  0    0   829   829   83%  02/12/2005    11:09 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm42            7020021010   70SP20030909  0    0   607   607   77%  02/12/2005    11:09 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm43            7020021010   70SP20030909  0    0   860   860   85%  02/12/2005    11:09 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm44            7020021010   70SP20030909  0    0  1198  1198   90%  02/12/2005    11:09 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm45            7020021010   70SP20030909  0    0   416   416   67%  02/12/2005    11:09 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm46            7020021010   70SP20030909  0    0   794   794   82%  02/12/2005    11:09 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm47            7020021010   70SP20030909  0    0   416   416   67%  02/12/2005    11:09 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm48            7020021010   70SP20030909  0    0   421   421   68%  02/12/2005    11:09 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm49            7020021010   70SP20030909  0    0   700   700   80%  02/12/2005    11:09 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm50            7020021010   70SP20030909  0    0   500   500   72%  02/12/2005    11:09 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm51            7020021010   70SP20030909  0    0   531   531   77%  02/12/2005    11:10 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm52            7020021010   70SP20030909  0    0   520   520   74%  02/12/2005    11:10 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm53            7020021010   70SP20030909  0    0   789   789   82%  02/12/2005    11:10 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm54            7020021010   70SP20030909  0    0   564   564   75%  02/12/2005    11:10 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm55            7020021010   70SP20030909  0    0   995   995   87%  02/12/2005    11:10 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm56            7020021010   70SP20030909  0    0  1577  1577   91%  02/12/2005    11:10 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm57            7020021010   70SP20030909  0    0   737   737   81%  02/12/2005    11:10 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm58            7020021010   70SP20030909  0    0   580   580   76%  02/12/2005    11:10 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm59            7020021010   70SP20030909  0    0   833   833   84%  02/12/2005    11:10 INTEL_NT
INTEL_NT         QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
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vm60	7020021010	70SP20030909	0	0	537	537	72%	02/12/2005	11:10	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm61	7020021010	70SP20030909	0	0	402	402	66%	02/12/2005	11:10	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm62	7020021010	70SP20030909	0	0	755	755	82%	02/12/2005	11:10	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm63	7020021010	70SP20030909	0	0	1280	1280	89%	02/12/2005	11:10	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm64	7020021010	70SP20030909	0	0	510	510	74%	02/12/2005	11:10	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm65	7020021010	70SP20030909	0	0	3323	3323	96%	02/12/2005	11:11	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm66	7020021010	70SP20030909	0	0	516	516	74%	02/12/2005	11:11	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm67	7020021010	70SP20030909	0	0	591	591	76%	02/12/2005	11:11	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm68	7020021010	70SP20030909	0	0	739	739	80%	02/12/2005	11:11	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm69	7020021010	70SP20030909	0	0	553	553	75%	02/12/2005	11:11	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm70	7020021010	70SP20030909	0	0	940	940	86%	02/12/2005	11:11	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm71	7020021010	70SP20030909	0	0	1307	1307	87%	02/12/2005	11:11	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm72	7020021010	70SP20030909	0	0	2161	2161	90%	02/12/2005	11:11	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm73	7020021010	70SP20030909	0	0	4189	4189	97%	02/12/2005	11:12	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm74	7020021010	70SP20030909	0	0	855	855	81%	02/12/2005	11:12	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm75	7020021010	70SP20030909	0	0	1129	1129	84%	02/12/2005	11:12	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm76	7020021010	70SP20030909	0	0	1187	1187	89%	02/12/2005	11:12	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm77	7020021010	70SP20030909	0	0	876	876	82%	02/12/2005	11:12	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm78	7020021010	70SP20030909	0	0	872	872	86%	02/12/2005	11:12	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm79	7020021010	70SP20030909	0	0	954	954	83%	02/12/2005	11:12	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm80	7020021010	70SP20030909	0	0	2205	2205	92%	02/12/2005	11:12	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS

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 vm81              7020021010    70SP20030909   0    0  2015  2015   93%  02/12/2005    11:13 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm82              7020021010    70SP20030909   0    0  2144  2144   94%  02/12/2005    11:13 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm83              7020021010    70SP20030909   0    0  2191  2191   94%  02/12/2005    11:13 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm84              7020021010    70SP20030909   0    0   821   821   82%  02/12/2005    11:13 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm85              7020021010    70SP20030909   0    0   858   858   84%  02/12/2005    11:13 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm86              7020021010    70SP20030909   0    0   428   428   68%  02/12/2005    11:13 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm87              7020021010    70SP20030909   0    0   434   434   69%  02/12/2005    11:13 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm88              7020021010    70SP20030909   0    0   450   450   70%  02/12/2005    11:14 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm89              7020021010    70SP20030909   0    0   480   480   72%  02/12/2005    11:14 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm90              7020021010    70SP20030909   0    0   761   761   82%  02/12/2005    11:14 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm91              7020021010    70SP20030909   0    0  2102  2102   94%  02/12/2005    11:14 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm92              7020021010    70SP20030909   0    0   501   501   73%  02/12/2005    11:14 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm93              7020021010    70SP20030909   0    0   436   436   69%  02/12/2005    11:14 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm94              7020021010    70SP20030909   0    0   508   508   73%  02/12/2005    11:14 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm95              7020021010    70SP20030909   0    0  1044  1044   86%  02/12/2005    11:14 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm96              7020021010    70SP20030909   0    0   633   633   78%  02/12/2005    11:14 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm97              7020021010    70SP20030909   0    0   809   809   83%  02/12/2005    11:14 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm98              7020021010    70SP20030909   0    0   703   703   80%  02/12/2005    11:14 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm99              7020021010    70SP20030909   0    0   482   482   72%  02/12/2005    11:14 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm100             7020021010    70SP20030909   0    0   642   642   79%  02/12/2005    11:14 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm101             7020021010    70SP20030909   0    0   720   720   81%  02/12/2005    11:14 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm102            7020021010    70SP20030909   0     0   761   761   82%  02/12/2005    11:15 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm103            7020021010    70SP20030909   0     0   782   782   84%  02/12/2005    11:15 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm104            7020021010    70SP20030909   0     0  1822  1822   93%  02/12/2005    11:15 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm105            7020021010    70SP20030909   0     0   589   589   77%  02/12/2005    11:15 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm106            7020021010    70SP20030909   0     0   432   432   69%  02/12/2005    11:15 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm107            7020021010    70SP20030909   0     0   476   476   72%  02/12/2005    11:15 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm108            7020021010    70SP20030909   0     0   437   437   69%  02/12/2005    11:15 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm109            7020021010    70SP20030909   0     0  1025  1025   87%  02/12/2005    11:15 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm110            7020021010    70SP20030909   0     0   743   743   82%  02/12/2005    11:15 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm111            7020021010    70SP20030909   0     0  3511  3511   96%  02/12/2005    11:16 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm112            7020021010    70SP20030909   0     0   726   726   81%  02/12/2005    11:16 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm113            7020021010    70SP20030909   0     0   732   732   82%  02/12/2005    11:17 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm114            7020021010    70SP20030909   0     0   693   693   80%  02/12/2005    11:17 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm115            7020021010    70SP20030909   0     0   604   604   78%  02/12/2005    11:17 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm116            7020021010    70SP20030909   0     0   830   830   84%  02/12/2005    11:17 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm117            7020021010    70SP20030909   0     0  1048  1048   86%  02/12/2005    11:17 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm118            7020021010    70SP20030909   0     0   918   918   85%  02/12/2005    11:17 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm119            7020021010    70SP20030909   0     0  1225  1225   89%  02/12/2005    11:17 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm120            7020021010    70SP20030909   0     0   485   485   72%  02/12/2005    11:17 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm121            7020021010    70SP20030909   0     0   811   811   83%  02/12/2005    11:18 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm122            7020021010    70SP20030909   0     0   422   422   68%  02/12/2005    11:18 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm123           7020021010    70SP20030909  0    0   467   467   71%  02/12/2005    11:18 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm124           7020021010    70SP20030909  0    0   591   591   77%  02/12/2005    11:18 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm125           7020021010    70SP20030909  0    0   762   762   82%  02/12/2005    11:18 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm126           7020021010    70SP20030909  0    0   661   661   80%  02/12/2005    11:18 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm127           7020021010    70SP20030909  0    0   625   625   79%  02/12/2005    11:18 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm128           7020021010    70SP20030909  0    0   815   815   83%  02/12/2005    11:18 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm129           7020021010    70SP20030909  0    0   373   373   66%  02/12/2005    11:18 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm130           7020021010    70SP20030909  0    0   553   553   78%  02/12/2005    11:18 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm131           7020021010    70SP20030909  0    0   448   448   70%  02/12/2005    11:18 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm132           7020021010    70SP20030909  0    0  1827  1827   93%  02/12/2005    11:18 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm133           7020021010    70SP20030909  0    0  1701  1701   92%  02/12/2005    11:18 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm134           7020021010    70SP20030909  0    0  1808  1808   93%  02/12/2005    11:19 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm135           7020021010    70SP20030909  0    0   561   561   77%  02/12/2005    11:19 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm136           7020021010    70SP20030909  0    0  1909  1909   93%  02/12/2005    11:19 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm137           7020021010    70SP20030909  0    0  1395  1395   91%  02/12/2005    11:19 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm138           7020021010    70SP20030909  0    0   528   528   75%  02/12/2005    11:19 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm139           7020021010    70SP20030909  0    0  1132  1132   88%  02/12/2005    11:19 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm140           7020021010    70SP20030909  0    0  1184  1184   89%  02/12/2005    11:19 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm141           7020021010    70SP20030909  0    0  2040  2040   93%  02/12/2005    11:19 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm142           7020021010    70SP20030909  0    0   879   879   85%  02/12/2005    11:19 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm143           7020021010    70SP20030909  0    0  1672  1672   91%  02/12/2005    11:20 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm144             7020021010    70SP20030909   0     0  2164  2164   94%  02/12/2005    11:20 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm145             7020021010    70SP20030909   0     0   532   532   75%  02/12/2005    11:20 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm146             7020021010    70SP20030909   0     0   883   883   86%  02/12/2005    11:20 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm147             7020021010    70SP20030909   0     0   588   588   77%  02/12/2005    11:20 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm148             7020021010    70SP20030909   0     0   588   588   78%  02/12/2005    11:20 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm149             7020021010    70SP20030909   0     0   520   520   74%  02/12/2005    11:20 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm150             7020021010    70SP20030909   0     0   657   657   79%  02/12/2005    11:20 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm151             7020021010    70SP20030909   0     0  1058  1058   87%  02/12/2005    11:20 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm152             7020021010    70SP20030909   0     0  1211  1211   88%  02/12/2005    11:20 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm153             7020021010    70SP20030909   0     0   507   507   74%  02/12/2005    11:20 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm154             7020021010    70SP20030909   0     0   814   814   82%  02/12/2005    11:20 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm155             7020021010    70SP20030909   0     0  1255  1255   89%  02/12/2005    11:24 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm156             7020021010    70SP20030909   0     0  2047  2047   94%  02/12/2005    11:24 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm157             7020021010    70SP20030909   0     0   952   952   85%  02/12/2005    11:24 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm158             7020021010    70SP20030909   0     0   955   955   87%  02/12/2005    11:25 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm159             7020021010    70SP20030909   0     0  1524  1524   91%  02/12/2005    11:25 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm160             7020021010    70SP20030909   0     0   600   600   78%  02/12/2005    11:25 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm161             7020021010    70SP20030909   0     0   539   539   75%  02/12/2005    11:25 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm162             7020021010    70SP20030909   0     0   548   548   76%  02/12/2005    11:25 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm163             7020021010    70SP20030909   0     0   563   563   76%  02/12/2005    11:25 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm164             7020021010    70SP20030909   0     0   556   556   76%  02/12/2005    11:25 INTEL_NT
INTEL_NT          QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm165          7020021010   70SP20030909  0    0   703   703   80%  02/12/2005    11:25 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm166          7020021010   70SP20030909  0    0   700   700   80%  02/12/2005    11:25 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm167          7020021010   70SP20030909  0    0  1138  1138   88%  02/12/2005    11:25 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm168          7020021010   70SP20030909  0    0   687   687   81%  02/12/2005    11:25 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm169          7020021010   70SP20030909  0    0   777   777   82%  02/12/2005    11:25 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm170          7020021010   70SP20030909  0    0   436   436   69%  02/12/2005    11:25 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm171          7020021010   70SP20030909  0    0   759   759   82%  02/12/2005    11:25 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm172          7020021010   70SP20030909  0    0  1528  1528   90%  02/12/2005    11:25 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm173          7020021010   70SP20030909  0    0   545   545   75%  02/12/2005    11:26 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm174          7020021010   70SP20030909  0    0   602   602   77%  02/12/2005    11:26 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm175          7020021010   70SP20030909  0    0   855   855   84%  02/12/2005    11:26 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm176          7020021010   70SP20030909  0    0   999   999   86%  02/12/2005    11:26 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm177          7020021010   70SP20030909  0    0  1127  1127   87%  02/12/2005    11:26 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm178          7020021010   70SP20030909  0    0   679   679   80%  02/12/2005    11:26 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm179          7020021010   70SP20030909  0    0   768   768   82%  02/12/2005    11:27 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm180          7020021010   70SP20030909  0    0   651   651   79%  02/12/2005    11:27 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm181          7020021010   70SP20030909  0    0   484   484   71%  02/12/2005    11:27 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm182          7020021010   70SP20030909  0    0   973   973   87%  02/12/2005    11:27 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm183          7020021010   70SP20030909  0    0   722   722   81%  02/12/2005    11:27 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm184          7020021010   70SP20030909  1    5  3162  3162   95%  02/12/2005    11:27 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm185          7020021010   70SP20030909  0    0   738   738   81%  02/12/2005    11:27 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm186            7020021010    70SP20030909  0    0  1392  1392   91%  02/12/2005    11:27 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm187            7020021010    70SP20030909  0    0  1489  1489   90%  02/12/2005    11:28 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm188            7020021010    70SP20030909  0    0   658   658   79%  02/12/2005    11:28 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm189            7020021010    70SP20030909  0    0  1067  1067   87%  02/12/2005    11:28 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm190            7020021010    70SP20030909  0    0   715   715   81%  02/12/2005    11:28 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm191            7020021010    70SP20030909  0    0  3075  3075   95%  02/12/2005    11:28 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm192            7020021010    70SP20030909  0    0   645   645   80%  02/12/2005    11:28 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm193            7020021010    70SP20030909  0    0   411   411   68%  02/12/2005    11:28 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm194            7020021010    70SP20030909  0    0   821   821   83%  02/12/2005    11:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm195            7020021010    70SP20030909  0    0   824   824   84%  02/12/2005    11:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm196            7020021010    70SP20030909  0    0   505   505   73%  02/12/2005    11:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm197            7020021010    70SP20030909  0    0   509   509   74%  02/12/2005    11:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm198            7020021010    70SP20030909  2    0  1208  1208   88%  02/12/2005    11:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm199            7020021010    70SP20030909  0    0   835   835   84%  02/12/2005    11:30 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm200            7020021010    70SP20030909  0    0  1258  1258   89%  02/12/2005    11:32 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm201            7020021010    70SP20030909  0    0  3072  3072   95%  02/12/2005    11:32 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm202            7020021010    70SP20030909  0    0   604   604   77%  02/12/2005    11:32 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm203            7020021010    70SP20030909  0    0  1020  1020   87%  02/12/2005    11:32 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm204            7020021010    70SP20030909  0    0   621   621   79%  02/12/2005    11:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm205            7020021010    70SP20030909  0    0   652   652   79%  02/12/2005    11:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm206            7020021010    70SP20030909  0    0   903   903   84%  02/12/2005    11:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm207              7020021010    70SP20030909   0     0  1079  1079   87%  02/12/2005    11:33 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm208              7020021010    70SP20030909   0     0   701   701   82%  02/12/2005    11:33 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm209              7020021010    70SP20030909   0     0  3159  3159   96%  02/12/2005    11:34 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm210              7020021010    70SP20030909   0     0  1426  1426   90%  02/12/2005    11:35 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm211              7020021010    70SP20030909   0     0  2658  2658   94%  02/12/2005    11:36 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm212              7020021010    70SP20030909   0     0  1041  1041   86%  02/12/2005    11:36 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm213              7020021010    70SP20030909   0     0   687   687   80%  02/12/2005    11:36 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm214              7020021010    70SP20030909   0     0   557   557   76%  02/12/2005    11:36 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm215              7020021010    70SP20030909   0     0   637   637   80%  02/12/2005    11:36 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm216              7020021010    70SP20030909   0     0  1111  1111   87%  02/12/2005    11:37 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm217              7020021010    70SP20030909   0     0   873   873   84%  02/12/2005    11:37 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm218              7020021010    70SP20030909   0     0   744   744   82%  02/12/2005    11:37 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm219              7020021010    70SP20030909   0     0   698   698   81%  02/12/2005    11:38 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm220              7020021010    70SP20030909   0     0   477   477   75%  02/12/2005    11:38 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm221              7020021010    70SP20030909   0     0   605   605   80%  02/12/2005    11:39 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm222              7020021010    70SP20030909   0     0  1536  1536   91%  02/12/2005    11:39 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm223              7020021010    70SP20030909   0     0   484   484   74%  02/12/2005    11:39 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm224              7020021010    70SP20030909   0     0   577   577   79%  02/12/2005    11:39 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm225              7020021010    70SP20030909   0     0   496   496   73%  02/12/2005    11:39 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm226              7020021010    70SP20030909   0     0  1622  1622   91%  02/12/2005    11:42 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm227              7020021010    70SP20030909   0     0   957   957   87%  02/12/2005    11:42 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm228              7020021010    70SP20030909   0    0  5849  5849   98%  02/12/2005    11:42 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm229              7020021010    70SP20030909   0    0  3944  3944   97%  02/12/2005    11:43 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm230              7020021010    70SP20030909   0    0 26798 26798   99%  02/12/2005    12:03 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm231              7020021010    70SP20030909   0    0   528   528   76%  02/12/2005    12:03 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm232              7020021010    70SP20030909   0    0 14057 14057   98%  02/12/2005    12:10 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm233              7020021010    70SP20030909   0    0   583   583   80%  02/12/2005    12:12 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm234              7020021010    70SP20030909   0    0  1468  1468   92%  02/12/2005    12:17 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm235              7020021010    70SP20030909   0    0   769   769   81%  02/12/2005    12:17 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm236              7020021010    70SP20030909   0    0  1760  1760   92%  02/12/2005    12:18 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc1               7020021010    70SP20030909   0    0   643   643   81%  02/12/2005    12:19 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc2               7020021010    70SP20030909   0    0  1692  1692   90%  02/12/2005    12:19 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc3               7020021010    70SP20030909   0    0   426   426   72%  02/12/2005    12:20 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc4               7020021010    70SP20030909   0    0   773   773   85%  02/12/2005    12:20 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc5               7020021010    70SP20030909   0    0   513   513   78%  02/12/2005    12:21 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc6               7020021010    70SP20030909   0    0   433   433   74%  02/12/2005    12:22 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc7               7020021010    70SP20030909   0    0   337   337   67%  02/12/2005    12:22 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc8               7020021010    70SP20030909   2    0  1894  1894   92%  02/12/2005    12:56 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmd1               7020021010    70SP20030909   0    0   816   816   86%  02/12/2005    12:57 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmd2               7020021010    70SP20030909   0    0   337   337   67%  02/12/2005    12:57 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmd3               7020021010    70SP20030909   0    0   608   608   82%  02/12/2005    12:59 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 cyc-177s           7020021010    70SP20030909   1    0  1219  1222   91%  02/12/2005    13:01 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
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 cyc-178s         7020021010    70SP20030909   1    0  1219  1222   91%  02/12/2005    13:04 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 dds-13s          7020021010    NO_UPDATE    -88    0   402   146   49%  02/12/2005    13:04 INTEL_NT
NOT_AVAILABLE     QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 dds-17s          7020021010    NO_UPDATE    -88    0   746   146   67%  02/12/2005    13:04 INTEL_NT
NOT_AVAILABLE     QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 esp-112s         7020021010    70SP20030909   0    0   279   279   58%  02/12/2005    13:04 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 esp-124s         7020021010    70SP20030909   0    0   392   392   66%  02/12/2005    13:04 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 esp-127s         7020021010    70SP20030909   0    0   527   527   75%  02/12/2005    13:04 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ess-26s          7020021010    70SP20030909   0    0  1846  1846   92%  02/12/2005    13:04 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ess-97s          7020021010    70SP20030909   0    0  1378  1378   90%  02/12/2005    13:04 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev117-106s       7020021010    70SP20030909   0    0  1333  1333   91%  02/12/2005    13:04 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev119-35s        7020021010    70SP20030909   0    0   506   506   74%  02/12/2005    13:04 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev120-85s        7020021010    70SP20030909   0    0   411   411   71%  02/12/2005    13:04 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev141-208s       7020021010    70SP20030909   0    0   341   341   66%  02/12/2005    13:04 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev144-13s        7020021010    70SP20030909   0    8  8804  8804   98%  02/12/2005    13:07 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev144-23s        7020021010    70SP20030909   0    0  1740  1740   92%  02/12/2005    13:10 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev154-23s        7020021010    70SP20030909   0    0  1259  1259   89%  02/12/2005    13:10 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev154-25s        7020021010    70SP20030909   0    0   587   587   76%  02/12/2005    13:10 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev171-57s        7020021010    70SP20030909   0    0   542   542   79%  02/12/2005    13:10 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev173-53s        7020021010    70SP20030909   1    0  1426  1429   92%  02/12/2005    13:11 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev174-46s        7020021010    70SP20030909   0    0   562   562   80%  02/12/2005    13:11 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev175-20s        7020021010    70SP20030909   1    0   538   541   79%  02/12/2005    13:11 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev175-21s        7020021010    NO_UPDATE    -88    0   566   146   64%  02/12/2005    13:11 INTEL_NT
NOT_AVAILABLE     QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
```

ev175-38s	7020021010	70SP20030909	0	0	808	808	85%	02/12/2005	13:11	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev182-zbdpg11s	7020021010	70SP20030909	0	0	660	660	83%	02/12/2005	13:11	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev183-zdpl20s	7020021010	70SP20030909	0	0	577	577	80%	02/12/2005	13:11	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev184-02s	7020021010	70SP20030909	0	0	267	267	56%	02/12/2005	13:12	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev184-07s	7020021010	70SP20030909	0	0	661	661	80%	02/12/2005	13:12	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev35-23s	7020021010	70SP20030909	0	0	293	293	61%	02/12/2005	13:12	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev95-45s	7020021010	70SP20030909	0	0	892	892	85%	02/12/2005	13:12	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev97-73s	7020021010	70SP20030909	0	0	621	621	82%	02/12/2005	13:12	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
flo-136s	7020021010	70SP20030909	0	0	419	419	73%	02/12/2005	13:12	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
flo-138s	7020021010	70SP20030909	0	0	352	352	68%	02/12/2005	13:13	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
inrt-16s	7020021010	70SP20030909	1	0	484	486	77%	02/12/2005	13:13	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
inrt-9s	7020021010	70SP20030909	0	0	421	421	73%	02/12/2005	13:13	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
mvhy-bk501	7020021010	70SP20030909	0	0	536	536	78%	02/12/2005	13:13	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
mvhy-gt202	7020021010	70SP20030909	0	0	780	780	84%	02/12/2005	13:14	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
mvve-cr003	7020021010	70SP20030909	0	0	328	328	65%	02/12/2005	13:15	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
mvve-cr804	7020021010	70SP20030909	0	0	329	329	65%	02/12/2005	13:16	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
se-1s	7020021010	70SP20030909	0	0	400	400	72%	02/12/2005	13:16	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
se-20s	7020021010	70SP20030909	0	0	879	879	85%	02/12/2005	13:16	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
sx120-1s	7020021010	NO_UPDATE	-88	0	248	146	30%	02/12/2005	13:16	INTEL_NT	NOT_AVAILABLE	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
tbc-155s	7020021010	70SP20030909	0	0	351	351	64%	02/12/2005	13:16	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS

```
1

 *****************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=c0231  10:37:04  OCT 15, 2002 CP=      0.219
 T= CURRENT JOBNAME=c0231  11:04:48  FEB 12, 2005 CP=      0.156

               0  /verify,c0231

               0  /title, c0231 (fsk) Unmatched nodes mapping

 COMPARE DIFFERENCE FOUND AT            NG=  192 NT=  192
 G=  NODAL RESULTS ARE FOR CYCLIC SECTOR   1 - PHASE ANGLE =     30.580
 T=  NODAL RESULTS ARE FOR CYCLIC SECTOR   1 - PHASE ANGLE =    237.330

 COMPARE DIFFERENCE FOUND AT            NG=  219 NT=  219
 G=  NODAL RESULTS ARE FOR CYCLIC SECTOR   2 - PHASE ANGLE =     30.580
 T=  NODAL RESULTS ARE FOR CYCLIC SECTOR   2 - PHASE ANGLE =    237.330

 COMPARE DIFFERENCE FOUND AT            NG=  246 NT=  246
 G=  NODAL RESULTS ARE FOR CYCLIC SECTOR   3 - PHASE ANGLE =     30.580
 T=  NODAL RESULTS ARE FOR CYCLIC SECTOR   3 - PHASE ANGLE =    237.330

 BOTTOM OF GOOD FILE REACHED AT LINE    289
 G= |                              ANSYS RUN COMPLETED                              |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       3                       *
 ************************************************


 ================================================================================
  PROBLEM: c0231            COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE   = 1.0000E-006            MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
```

```
                                              GREAD, TREAD =    1,   1
===============================================================================

LINES ON GOOD FILE =      304
LINES ON TEST FILE =      304
****************************************************************************
```

```
1

 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=vm184  20:46:18  OCT 15, 2002 CP=      0.250
 T= CURRENT JOBNAME=vm184  11:27:32  FEB 12, 2005 CP=      0.297

              0  /VERIFY,VM184

              0  /TITLE, VM184, STRAIGHT CANTILEVER BEAM

              0  /stitle,1,Reason COMPARE differences are acceptable:

              0  /stitle,2,  mesher accuracy - element number on warning; near-
zero values

              0  /TITLE, VM184, STRAIGHT CANTILEVER BEAM

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 ABSOLUTE VALUE DIFFERENCE FOUND AT     NG=  926 NT=  926
 G= VALUE  -0.24849E-01 0.98917    -0.43496E-05 0.98948
 T= VALUE  -0.24849E-01 0.98917     0.43497E-05 0.98948

 ABSOLUTE VALUE DIFFERENCE FOUND AT     NG=  982 NT=  982
 G= VALUE  -0.53544E-02-0.26671E-05 0.42554     0.42557
 T= VALUE  -0.53544E-02 0.26671E-05 0.42554     0.42557

 ABSOLUTE VALUE DIFFERENCE FOUND AT     NG= 1011 NT= 1011
 G= VALUE  -0.12394E-01-0.61739E-05 0.98504     0.98511
 T= VALUE  -0.12394E-01 0.61739E-05 0.98504     0.98511

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 COMPARE DIFFERENCE FOUND AT            NG= 1580 NT= 1580
 G= VALUE   0.24811E-01 0.98813    -0.43696E-05 0.98844
 T= VALUE   0.24811E-01 0.98813     0.43701E-05 0.98844

 ABSOLUTE VALUE DIFFERENCE FOUND AT     NG= 1639 NT= 1639
 G= VALUE  -0.53533E-02-0.30755E-05 0.42553     0.42556
```

```
 T= VALUE  -0.53533E-02 0.30756E-05 0.42553     0.42556

 ABSOLUTE VALUE DIFFERENCE FOUND AT     NG= 1673 NT= 1673
 G= VALUE  -0.12392E-01-0.71193E-05 0.98502     0.98510
 T= VALUE  -0.12392E-01 0.71194E-05 0.98502     0.98510

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 BOTTOM OF GOOD FILE REACHED AT LINE   3147
 G= |                            ANSYS RUN COMPLETED                             |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************



 *****************************************************
 WARNING -      5 ABSOLUTE VALUE DIFFERENCE(S) FOUND.
 *****************************************************


 ************************************************************
 NOTE -   1 summary line(s) contained absolute value differences.
 ************************************************************

 ================================================================================
  PROBLEM: vm184           COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004              MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE   = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                 KNOWN  (# OF KNOWN ERRS)=   0
```

```
                                              GREAD, TREAD =     1,    1
================================================================================

LINES ON GOOD FILE =      3162
LINES ON TEST FILE =      3162
*****************************************************************************
```

```
1
 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=vm198  20:50:49  OCT 15, 2002 CP=      0.266
 T= CURRENT JOBNAME=vm198  11:29:13  FEB 12, 2005 CP=      0.172

              0  /VERIFY,VM198

              0  /TITLE, VM198, LARGE STRAIN IN-PLANE TORSION TEST (%EL%)

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 COMPARE DIFFERENCE FOUND AT            NG=  618 NT=  618
 G= RELEASE  0.0      UPDATE        0   CUSTOMER  00000000
 T= RELEASE  0.0      UPDATE        0   CUSTOMER  00292062

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 COMPARE DIFFERENCE FOUND AT            NG=  907 NT=  907
 G= RELEASE  0.0      UPDATE        0   CUSTOMER  00000000
 T= RELEASE  0.0      UPDATE        0   CUSTOMER  00292062

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****
```

```
BOTTOM OF GOOD FILE REACHED AT LINE   1193
G= |                              ANSYS RUN COMPLETED                                  |


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NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

************************************************
COMPARE ERRORS =       2                       *
************************************************


================================================================================
 PROBLEM: vm198            COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

ALMOST ZERO (GOOD)    = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
ALMOST ZERO (TEST)    = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
ABSOLUTE VALUE TOL    = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                               KNOWN  (# OF KNOWN ERRS)=   0
                                               GREAD, TREAD =    1,   1
================================================================================

LINES ON GOOD FILE =      1208
LINES ON TEST FILE =      1208
*****************************************************************************
```

```
1
 ****************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=vmc8  21:52:06  OCT 15, 2002 CP=      0.219
 T= CURRENT JOBNAME=vmc8  12:22:49  FEB 12, 2005 CP=      0.188

               0  /VERIFY,VMC8

               0  /TITLE, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY

               0  /stitle,1,Reason COMPARE differences are acceptable:

               0  /stitle,2,  number of iterations, accuracy

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
PLANE2

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
PLANE42

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
PLANE82

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
VISCO106

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
SOLID45

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
SOLID95

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
VISCO107

               0  /TITLE, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 COMPARE DIFFERENCE FOUND AT            NG=  880 NT=  880
 G= SET COMMAND GOT LOAD STEP=     2  SUBSTEP=   320  CUMULATIVE ITERATION=  3255
 T= SET COMMAND GOT LOAD STEP=     2  SUBSTEP=   320  CUMULATIVE ITERATION=  3240
```

```
 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****

 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****

 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****

 COMPARE DIFFERENCE FOUND AT            NG= 1227 NT= 1227
 G=   3 ESOL     1 EPPL EQV  EPPLEQV   0.7401E-16  0.000      3.410      0.000
 T=   3 ESOL     1 EPPL EQV  EPPLEQV   0.2694E-35  0.000      3.422      0.000

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****

 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****

 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****
```

```
 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 BOTTOM OF GOOD FILE REACHED AT LINE   1879
 G= |                               ANSYS RUN COMPLETED                              |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       2                       *
 ************************************************


 ================================================================================
  PROBLEM: vmc8             COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)   = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)   = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL   = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004            MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006            MAXBUF (# LINES TO SCAN)=   6
                                               KNOWN  (# OF KNOWN ERRS)=   0
                                               GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =     1894
 LINES ON TEST FILE =     1894
 *****************************************************************************
```

```
1

 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=cyc-177s  11:45:34  OCT 15, 2002 CP=      0.219
 T= CURRENT JOBNAME=cyc-177s  12:59:19  FEB 12, 2005 CP=      0.266

               0  /verify,cyc-177s

               0  /TITLE, ceb,cyc-177s, Test cyc symm Buckling element 42

               0  /title,1,Full Results to Sector Results!

               0  /stitle,Reason Compare differences are acceptable:

 EXTRA DATA SKIPPED ON TEST FILE        NG= 1202 NT= 1194
 T= USE COMMAND MACRO QAEND
 T= ARGS=   289.00
 END OF SKIPPED DATA                    NG= 1202 NT= 1199

 BOTTOM OF GOOD FILE REACHED AT LINE   1204
 G= |                            ANSYS RUN COMPLETED                            |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************


 ================================================================================
  PROBLEM: cyc-177s         COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)   = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)   = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL   = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004            MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006            MAXBUF (# LINES TO SCAN)=   6
                                               KNOWN  (# OF KNOWN ERRS)=   0
                                               GREAD, TREAD =    1,   1
 ================================================================================
```

```
LINES ON GOOD FILE =     1219
LINES ON TEST FILE =     1222
****************************************************************************
```

```
1

 ********************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=cyc-178s  11:48:41  OCT 15, 2002 CP=      0.250
 T= CURRENT JOBNAME=cyc-178s  13:01:42  FEB 12, 2005 CP=      0.234

               0  /verify,cyc-178s

               0  /TITLE, ceb,cyc-178s, Test cyc symm Buckling element 182

               0  /title,1,Full Results to Sector Results!

               0  /stitle,Reason Compare differences are acceptable:

 EXTRA DATA SKIPPED ON TEST FILE        NG= 1202 NT= 1194
 T= USE COMMAND MACRO QAEND
 T= ARGS=   289.00
 END OF SKIPPED DATA                    NG= 1202 NT= 1199

 BOTTOM OF GOOD FILE REACHED AT LINE   1204
 G= |                                ANSYS RUN COMPLETED                            |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 **************************************************
 COMPARE ERRORS =       1                        *
 **************************************************


 ================================================================================
  PROBLEM: cyc-178s         COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)   = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)   = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL   = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
                                                GREAD, TREAD =    1,   1
 ================================================================================
```

```
LINES ON GOOD FILE =     1219
LINES ON TEST FILE =     1222
****************************************************************************
```

```
1
 ****************************************************************************

   *** ERROR -- (VERSION=) was not found anywhere in the  "TEST" file.       ***
   *** Comparison was supposed to start at this string, specified in CMPOPT. ***

 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ***********************************************
 COMPARE ERRORS =     -88                      *
 ***********************************************

 ===============================================================================
  PROBLEM: dds-13s          COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)   = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)   = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL   = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
                                                GREAD, TREAD =    1,   1
 ===============================================================================

 LINES ON GOOD FILE =      402
 LINES ON TEST FILE =      146
 ****************************************************************************
```

```
1
 *****************************************************************************

   *** ERROR -- (VERSION=) was not found anywhere in the  "TEST" file.       ***
   *** Comparison was supposed to start at this string, specified in CMPOPT. ***

 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =     -88                       *
 ************************************************

 ================================================================================
  PROBLEM: dds-17s          COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004              MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006              MAXBUF (# LINES TO SCAN)=   6
                                                 KNOWN  (# OF KNOWN ERRS)=   0
                                                 GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =      746
 LINES ON TEST FILE =      146
 *****************************************************************************
```

```
1
 ****************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=ev173-53s  14:02:31  OCT 15, 2002 CP=      0.234
 T= CURRENT JOBNAME=ev173-53s  13:10:45  FEB 12, 2005 CP=      0.172

               0  /verify,ev173-53s

               0  /title,ev173-53s,mfquresh,Test to verify PSOVLE,ELFORM for 171-
175 (3D) with PENE

 EXTRA DATA SKIPPED ON TEST FILE        NG= 1409 NT= 1401
 T= USE COMMAND MACRO QAEND
 T= ARGS=   20.000
 END OF SKIPPED DATA                    NG= 1409 NT= 1406

 BOTTOM OF GOOD FILE REACHED AT LINE   1411
 G= |                           ANSYS RUN COMPLETED                           |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************


 ================================================================================
  PROBLEM: ev173-53s        COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)   = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)   = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL   = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004            MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006            MAXBUF (# LINES TO SCAN)=   6
                                               KNOWN  (# OF KNOWN ERRS)=   0
                                               GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =     1426
 LINES ON TEST FILE =     1429
 ****************************************************************************
```

```
1

 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=ev175-20s  14:22:03  OCT 15, 2002 CP=      0.250
 T= CURRENT JOBNAME=ev175-20s  13:11:18  FEB 12, 2005 CP=      0.156

              0  /verify,ev175-20s

              0  /title,ev175-20s,mfq, Check real constant FKN and FTOLN and
KEYOPT(2)=0,1

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 EXTRA DATA SKIPPED ON TEST FILE        NG=  521 NT=  513
 T= USE COMMAND MACRO QAEND
 T= ARGS=   3.0000
 END OF SKIPPED DATA                    NG=  521 NT=  518

 BOTTOM OF GOOD FILE REACHED AT LINE    523
 G= |                            ANSYS RUN COMPLETED                            |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************


 ================================================================================
  PROBLEM: ev175-20s        COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004            MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE   = 1.0000E-006            MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
                                                GREAD, TREAD =    1,   1
 ================================================================================
```

```
LINES ON GOOD FILE =      538
LINES ON TEST FILE =      541
******************************************************************************
```

```
1

 ******************************************************************************


   *** ERROR -- (VERSION=) was not found anywhere in the  "TEST" file.       ***
   *** Comparison was supposed to start at this string, specified in CMPOPT. ***


 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =     -88                       *
 ************************************************


 ================================================================================
  PROBLEM: ev175-21s        COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004              MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006              MAXBUF (# LINES TO SCAN)=   6
                                                 KNOWN  (# OF KNOWN ERRS)=   0
                                                 GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =      566
 LINES ON TEST FILE =      146
 ******************************************************************************
```

```
1

 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=inrt-16s  16:14:59  OCT 15, 2002 CP=      0.219
 T= CURRENT JOBNAME=inrt-16s  13:13:40  FEB 12, 2005 CP=      0.188

               0  /VERIFY,INRT-16S

               0  /TITLE, INRT-16S, ceb, component omega loading and layer
elements

               0  /TITLE, INRT-16S, BENDING OF A COMPOSITE BEAM

 EXTRA DATA SKIPPED ON TEST FILE        NG=  462 NT=  459
 T= USE COMMAND MACRO QAEND
 END OF SKIPPED DATA                    NG=  462 NT=  463

 BOTTOM OF GOOD FILE REACHED AT LINE    469
 G= |                           ANSYS RUN COMPLETED                            |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     1
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     1
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************


 ================================================================================
  PROBLEM: inrt-16s         COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004              MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE   = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                 KNOWN  (# OF KNOWN ERRS)=   0
                                                 GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =      484
 LINES ON TEST FILE =      486
```

****

```
1
 ****************************************************************************

   *** ERROR -- (VERSION=) was not found anywhere in the  "TEST" file.       ***
   *** Comparison was supposed to start at this string, specified in CMPOPT. ***

 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =     -88                       *
 ************************************************


 ================================================================================
  PROBLEM: sx120-1s         COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
                                                GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =      248
 LINES ON TEST FILE =      146
 ****************************************************************************
```

Software Acceptance

1) Project Title and Number: DST Thermal and Seismic Analyses 48971

2) Software Name and Version: ANSYS 7.0 (Rev. 11)

3) Computer and Property Number: Dell DHM WD44879

4) Operating System: Windows XP Professional Version 2002 Service Pack 2

4) Scope of Testing: Software reinstallation (XP SP2)

5) Tests: Execute ANSYS Verification Testing Package

6) Discrepancies:

n) c0231. These differences are acceptable per the ANSYS Verification Package User's Guide – ANSYS Release 7.0 (AVPUG).
o) vm184. These differences occur at the 5th significant figure.
p) vm198. This difference is the reporting of the customer number for this installation.
q) vmc8. These differences are acceptable as noted in the output because of the difference in number of iterations and accuracy.
r) cyc-177s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).
s) cyc-178s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).
t) dds-13s. This test case requires the "Parallel Performance Module" which is not part of this software installation and is not required for the DST analyses.
u) dds-17s. This test case requires the "Parallel Performance Module" which is not part of this software installation and is not required for the DST analyses.
v) ev173-53s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).
w) ev175-20s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).
x) ev175-21s. This test case requires the "Parallel Performance Module" which is not part of this software installation and is not required for the DST analyses.
y) inrt-16s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).
z) sx120-1s. This test case requires the "Frequency Sweep Module" which is not part of this software installation and is not required for the DST analyses.

7) Finding: This installation of ANSYS is acceptable

Certified by:

JE Deibler John E Deibler 2/24/05
Code Custodian

Reviewed by:

KI Johnson Kenneth I Johnson 4/16/05
Lead Engineer

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Notes for test case cO231

Test case cO231 may show considerable differences for the Phase Angle value that is part of the Post1 Nodal Degree of Freedom Listing (PRNS command) output. Any such differences do not indicate a problem with this test case's results and should be considered acceptable. The output items of significance for this test case are the UZ values in the Post1 Nodal Degree of Freedom Listing. Machine precision differences in the form of small numerical differences that are trivial with respect to the test's output items of significance may also show for this test case in the compare output for this test. Please see **Verifying ANSYS and Evaluating COMPARE Differences** in Chapter 2 of the *ANSYS Verification Testing Package User's Guide* for more information on evaluating COMPARE differences. The following is an example of acceptable COMPARE differences for test case cO231 :

COMPARE DIFFERENCE FOUND AT G= NODAL RESULTS ARE FOR CYCLIC SECTOR T= NODAL RESULTS ARE FOR CYCLIC SECTOR

COMPARE DIFFERENCE FOUND AT G= VALUE -9.8117 -3.7700 22. T= VALUE -9.8119 -3.7693 22.

COMPARE DIFFERENCE FOUND AT G= NODAL RESULTS ARE FOR CYCLIC SECTOR T= NODAL RESULTS ARE FOR CYCLIC SECTOR

COMPARE DIFFERENCE FOUND AT G= VALUE -9.7579 -3.9649 22. T= VALUE -9.7581 -3.9643 22.

```
COMPARE DIFFERENCE FOUND AT G= NODAL RESULTS ARE FOR CYCLIC SECTOR T= NODAL RESULTS ARE FOR CYCLIC SECTOR

COMPARE DIFFERENCE FOUWAT --~-c;;;i';; G= 8 0.53291 0.39425 io T= 8 0.53293 p.39419 10

COMPARE DIFFERENCE FOUND AT G= 10 0.52495 0.39568 9. T= 10 0.52497 0.39562 9.

COMPARE DIFFERENCE FOUND AT NG= 259 NT= 259 G= 12 0.50433 0.40282 8.6482 8.6722 T= 12 0.50435 0.40276 8.6471 8.6711

COMPARE DIFFERENCE FOUND AT NG= 260 NT= 260 G= 14 0.48186 0.41201 7.8710 7.8965 T= 14 0.48188 0.41196 7.8700 7.8955

COMPARE DIFFERENCE FOUND AT NG= 261 NT= 261 G= 16 0.45505 0.42478 7.0719 7.0992 T= 16 0.45507 0.42473 7.0710 7.0983

COMPARE DIFFERENCE FOUND AT NG= 262 NT= 262 G= 18 0.42339 0.44092 6.2424 6.2723 T= 18 0.42341 0.44086 6.2417 6.2715

COMPARE DIFFERENCE FOUND AT NG= 263 NT= 263 G= 20 0.38501 0.46124 5.3732 5.4067 T= 20 0.38502 0.46118 5.3726 5.4061

COMPARE DIFFERENCE FOUND AT NG= 267 NT= 267 G= VALUE -9.6034 -3.9649 18.806 21.413 T= VALUE -9.6036 -3.9643 18.805
21.412

NG= 271 NT= 271 22.469 24.766 22.469 24.766

NG= 192 NT= 192 1 -PHASE ANGLE = 1- PHASE ANGLE =

NG= 213 NT= 213 469 24.766 469 24.766

NG= 219 NT= 219 2- PHASE ANGLE = 2- PHASE ANGLE =

NG= 240 NT= 240 440 24.710 440 24.710

NG= 246 NT= 246 3- PHASE ANGLE = 3 -PHASE ANGLE =

NG-= 257 m-~-257 .161 10.183 .160 10.181

NG= 4080 4068

258 NT= 258 9.4309 9.4297

COMPARE DIFFERENCE FOUND AT G= VALUE -9.8117 -3.9649 T= VALUE -9.8119 -3.9643

30.580 306.570

30.580 306.570

30.580 306.570
```

Notes for Test Case vrn212

Test case vm212 may produce an expected compare difference due to an inconsequential warning message that appears in the ANSYS, Inc. supplied output file that may not appear in the output file generated by your system for this test case. This compare difference should be considered acceptable. The following is an example of this compare difference.

```
COMPARE DIFFERENCE FOUND AT            NG= 445 NT= 436
G= NUMBER OF WARNING MESSAGES ENCOUNTERED= 1
T= NUMBER OF WARNING MESSAGES ENCOUNTERED= 0
```

Notes for Test Cases cyc-177s, cyc-178s, ev-173-53s, ev-175-20s, inrt-16s, and inrt-9s

Test cases cyc-177s, cyc-178s, ev-173-53s, ev-175-20s, inrt-16s, and inrt-9s may produce expected compare differences due to the use of a macro named qaend. The method that is used in the verification procudure (runqa) to handle this macro may cause one or more comparison differences. Any such compare differences are inconsequential and should be considered acceptable. The following is an example of such a compare difference.

```
EXTRA DATA SKIPPED ON TEST FILE          NG= 1033 NT= 1030
T= USE COMMAND MACRO qaend
T= ARGS= 137.00
END OF SKIPPED DATA                      NG= 1033 NT= 1033
```

Notes for test Cases dds-13s, dds-17s, and ev175-21 s

The test cases dds-13s, dds-17s, and ev175-21 s will run to completion only if the "Parallel Performance for ANSYS" product (DDS and AMG solvers) is included in your ANSYS installation.

```
c0211r2          7020021010    70SP20030909   0    0   605   605   81%  02/12/2005    21:31 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0212            7020021010    70SP20030909   0    0   223   223   45%  02/12/2005    21:31 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0213            7020021010    70SP20030909   0    0   197   197   41%  02/12/2005    21:31 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0214            7020021010    70SP20030909   0    0   409   409   67%  02/12/2005    21:31 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0215            7020021010    70SP20030909   0    0   648   648   81%  02/12/2005    21:31 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0216            7020021010    70SP20030909   0    0   510   510   74%  02/12/2005    21:31 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0217            7020021010    70SP20030909   0    0   332   332   66%  02/12/2005    21:31 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0218            7020021010    70SP20030909   0    0  1627  1627   93%  02/12/2005    21:31 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0219            7020021010    70SP20030909   0    0  2732  2732   95%  02/12/2005    21:31 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0220            7020021010    70SP20030909   0    0   494   494   76%  02/12/2005    21:31 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0221            7020021010    70SP20030909   0    0  1265  1265   90%  02/12/2005    21:31 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0222            7020021010    70SP20030909   0    0  1543  1543   92%  02/12/2005    21:32 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0223            7020021010    70SP20030909   0    0   362   362   66%  02/12/2005    21:32 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0224            7020021010    70SP20030909   0    0   307   307   59%  02/12/2005    21:32 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0225            7020021010    70SP20030909   0    0   420   420   70%  02/12/2005    21:32 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0226            7020021010    70SP20030909   0    0   521   521   74%  02/12/2005    21:32 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0227            7020021010    70SP20030909   0    0   380   380   65%  02/12/2005    21:32 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0227a           7020021010    70SP20030909   0    0   380   380   65%  02/12/2005    21:32 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0228            7020021010    70SP20030909   0    0   236   236   50%  02/12/2005    21:32 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0229            7020021010    70SP20030909   0    0   715   715   81%  02/12/2005    21:32 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0230            7020021010    70SP20030909   0    0  2513  2513   94%  02/12/2005    21:33 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
```

```
 c0231            7020021010    70SP20030909   3    0   304   304   61%  02/12/2005     21:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0232            7020021010    70SP20030909   0    0   517   517   79%  02/12/2005     21:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0233            7020021010    70SP20030909   0    0   542   542   75%  02/12/2005     21:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0234            7020021010    70SP20030909   0    0   420   420   68%  02/12/2005     21:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm1              7020021010    70SP20030909   0    0   474   474   72%  02/12/2005     21:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm2              7020021010    70SP20030909   0    0   667   667   81%  02/12/2005     21:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm3              7020021010    70SP20030909   0    0   499   499   73%  02/12/2005     21:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm4              7020021010    70SP20030909   0    0   434   434   69%  02/12/2005     21:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm5              7020021010    70SP20030909   0    0   884   884   85%  02/12/2005     21:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm6              7020021010    70SP20030909   0    0   854   854   83%  02/12/2005     21:34 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm7              7020021010    70SP20030909   0    0  2176  2176   93%  02/12/2005     21:34 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm8              7020021010    70SP20030909   0    0   346   346   64%  02/12/2005     21:34 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm9              7020021010    70SP20030909   0    0   851   851   85%  02/12/2005     21:34 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm10             7020021010    70SP20030909   0    0   437   437   69%  02/12/2005     21:34 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm11             7020021010    70SP20030909   0    0   885   885   85%  02/12/2005     21:34 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm12             7020021010    70SP20030909   0    0   444   444   70%  02/12/2005     21:34 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm13             7020021010    70SP20030909   0    0   464   464   71%  02/12/2005     21:34 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm14             7020021010    70SP20030909   0    0   537   537   76%  02/12/2005     21:34 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm15             7020021010    70SP20030909   0    0  1356  1356   91%  02/12/2005     21:34 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm16             7020021010    70SP20030909   0    0   740   740   82%  02/12/2005     21:34 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm17             7020021010    70SP20030909   0    0   546   546   76%  02/12/2005     21:34 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm18             7020021010    70SP20030909  0    0   450   450   71%  02/12/2005    21:34 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm19             7020021010    70SP20030909  0    0   725   725   80%  02/12/2005    21:34 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm20             7020021010    70SP20030909  0    0   449   449   70%  02/12/2005    21:34 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm21             7020021010    70SP20030909  0    0   805   805   82%  02/12/2005    21:34 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm22             7020021010    70SP20030909  0    0   398   398   66%  02/12/2005    21:34 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm23             7020021010    70SP20030909  0    0  1043  1043   88%  02/12/2005    21:34 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm24             7020021010    70SP20030909  0    0   766   766   82%  02/12/2005    21:34 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm25             7020021010    70SP20030909  0    0  2350  2350   95%  02/12/2005    21:34 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm26             7020021010    70SP20030909  0    0  1829  1829   89%  02/12/2005    21:35 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm27             7020021010    70SP20030909  0    0   910   910   85%  02/12/2005    21:35 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm28             7020021010    70SP20030909  0    0   418   418   70%  02/12/2005    21:35 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm29             7020021010    70SP20030909  0    0   683   683   80%  02/12/2005    21:35 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm30             7020021010    70SP20030909  0    0   449   449   70%  02/12/2005    21:35 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm31             7020021010    70SP20030909  0    0   551   551   76%  02/12/2005    21:35 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm32             7020021010    70SP20030909  0    0   881   881   84%  02/12/2005    21:35 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm33             7020021010    70SP20030909  0    0   902   902   85%  02/12/2005    21:35 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm34             7020021010    70SP20030909  0    0  1380  1380   90%  02/12/2005    21:35 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm35             7020021010    70SP20030909  0    0   594   594   77%  02/12/2005    21:35 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm36             7020021010    70SP20030909  0    0  1086  1086   88%  02/12/2005    21:35 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm37             7020021010    70SP20030909  0    0   690   690   81%  02/12/2005    21:35 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm38             7020021010    70SP20030909  0    0  1667  1667   92%  02/12/2005    21:35 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
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vm39	7020021010	70SP20030909	0	0	819	819	84%	02/12/2005	21:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm40	7020021010	70SP20030909	0	0	876	876	86%	02/12/2005	21:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm41	7020021010	70SP20030909	0	0	829	829	83%	02/12/2005	21:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm42	7020021010	70SP20030909	0	0	607	607	77%	02/12/2005	21:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm43	7020021010	70SP20030909	0	0	860	860	85%	02/12/2005	21:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm44	7020021010	70SP20030909	0	0	1198	1198	90%	02/12/2005	21:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm45	7020021010	70SP20030909	0	0	416	416	67%	02/12/2005	21:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm46	7020021010	70SP20030909	0	0	794	794	82%	02/12/2005	21:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm47	7020021010	70SP20030909	0	0	416	416	67%	02/12/2005	21:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm48	7020021010	70SP20030909	0	0	421	421	68%	02/12/2005	21:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm49	7020021010	70SP20030909	0	0	700	700	80%	02/12/2005	21:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm50	7020021010	70SP20030909	0	0	500	500	72%	02/12/2005	21:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm51	7020021010	70SP20030909	0	0	531	531	77%	02/12/2005	21:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm52	7020021010	70SP20030909	0	0	520	520	74%	02/12/2005	21:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm53	7020021010	70SP20030909	0	0	789	789	82%	02/12/2005	21:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm54	7020021010	70SP20030909	0	0	564	564	75%	02/12/2005	21:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm55	7020021010	70SP20030909	0	0	995	995	87%	02/12/2005	21:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm56	7020021010	70SP20030909	0	0	1577	1577	91%	02/12/2005	21:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm57	7020021010	70SP20030909	0	0	737	737	81%	02/12/2005	21:37	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm58	7020021010	70SP20030909	0	0	580	580	76%	02/12/2005	21:37	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS
vm59	7020021010	70SP20030909	0	0	833	833	84%	02/12/2005	21:37	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL 3.8	UP20020121	WINDOWS

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 vm60               7020021010    70SP20030909   0    0   537   537   72%  02/12/2005    21:37 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm61               7020021010    70SP20030909   0    0   402   402   66%  02/12/2005    21:37 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm62               7020021010    70SP20030909   0    0   755   755   82%  02/12/2005    21:37 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm63               7020021010    70SP20030909   0    0  1280  1280   89%  02/12/2005    21:37 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm64               7020021010    70SP20030909   0    0   510   510   74%  02/12/2005    21:37 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm65               7020021010    70SP20030909   0    0  3323  3323   96%  02/12/2005    21:37 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm66               7020021010    70SP20030909   0    0   516   516   74%  02/12/2005    21:37 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm67               7020021010    70SP20030909   0    0   591   591   76%  02/12/2005    21:37 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm68               7020021010    70SP20030909   0    0   739   739   80%  02/12/2005    21:37 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm69               7020021010    70SP20030909   0    0   553   553   75%  02/12/2005    21:37 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm70               7020021010    70SP20030909   0    0   940   940   86%  02/12/2005    21:37 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm71               7020021010    70SP20030909   0    0  1307  1307   87%  02/12/2005    21:37 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm72               7020021010    70SP20030909   0    0  2161  2161   90%  02/12/2005    21:37 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm73               7020021010    70SP20030909   0    0  4189  4189   97%  02/12/2005    21:38 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm74               7020021010    70SP20030909   0    0   855   855   81%  02/12/2005    21:38 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm75               7020021010    70SP20030909   0    0  1129  1129   84%  02/12/2005    21:38 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm76               7020021010    70SP20030909   0    0  1187  1187   89%  02/12/2005    21:38 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm77               7020021010    70SP20030909   0    0   876   876   82%  02/12/2005    21:38 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm78               7020021010    70SP20030909   0    0   872   872   86%  02/12/2005    21:38 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm79               7020021010    70SP20030909   0    0   954   954   83%  02/12/2005    21:38 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm80               7020021010    70SP20030909   0    0  2205  2205   92%  02/12/2005    21:38 INTEL_NT
INTEL_NT           QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm81             7020021010    70SP20030909   0    0  2015  2015   93%  02/12/2005    21:38 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm82             7020021010    70SP20030909   0    0  2144  2144   94%  02/12/2005    21:38 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm83             7020021010    70SP20030909   0    0  2191  2191   94%  02/12/2005    21:38 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm84             7020021010    70SP20030909   0    0   821   821   82%  02/12/2005    21:38 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm85             7020021010    70SP20030909   0    0   858   858   84%  02/12/2005    21:38 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm86             7020021010    70SP20030909   0    0   428   428   68%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm87             7020021010    70SP20030909   0    0   434   434   69%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm88             7020021010    70SP20030909   0    0   450   450   70%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm89             7020021010    70SP20030909   0    0   480   480   72%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm90             7020021010    70SP20030909   0    0   761   761   82%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm91             7020021010    70SP20030909   0    0  2102  2102   94%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm92             7020021010    70SP20030909   0    0   501   501   73%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm93             7020021010    70SP20030909   0    0   436   436   69%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm94             7020021010    70SP20030909   0    0   508   508   73%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm95             7020021010    70SP20030909   0    0  1044  1044   86%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm96             7020021010    70SP20030909   0    0   633   633   78%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm97             7020021010    70SP20030909   0    0   809   809   83%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm98             7020021010    70SP20030909   0    0   703   703   80%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm99             7020021010    70SP20030909   0    0   482   482   72%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm100            7020021010    70SP20030909   0    0   642   642   79%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm101            7020021010    70SP20030909   0    0   720   720   81%  02/12/2005    21:39 INTEL_NT
INTEL_NT         QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm102          7020021010   70SP20030909  0    0   761   761   82%  02/12/2005    21:39 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm103          7020021010   70SP20030909  0    0   782   782   84%  02/12/2005    21:39 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm104          7020021010   70SP20030909  0    0  1822  1822   93%  02/12/2005    21:40 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm105          7020021010   70SP20030909  0    0   589   589   77%  02/12/2005    21:40 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm106          7020021010   70SP20030909  0    0   432   432   69%  02/12/2005    21:40 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm107          7020021010   70SP20030909  0    0   476   476   72%  02/12/2005    21:40 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm108          7020021010   70SP20030909  0    0   437   437   69%  02/12/2005    21:40 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm109          7020021010   70SP20030909  0    0  1025  1025   87%  02/12/2005    21:40 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm110          7020021010   70SP20030909  0    0   743   743   82%  02/12/2005    21:40 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm111          7020021010   70SP20030909  0    0  3511  3511   96%  02/12/2005    21:41 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm112          7020021010   70SP20030909  0    0   726   726   81%  02/12/2005    21:41 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm113          7020021010   70SP20030909  0    0   732   732   82%  02/12/2005    21:41 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm114          7020021010   70SP20030909  0    0   693   693   80%  02/12/2005    21:41 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm115          7020021010   70SP20030909  0    0   604   604   78%  02/12/2005    21:41 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm116          7020021010   70SP20030909  0    0   830   830   84%  02/12/2005    21:41 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm117          7020021010   70SP20030909  0    0  1048  1048   86%  02/12/2005    21:41 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm118          7020021010   70SP20030909  0    0   918   918   85%  02/12/2005    21:41 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm119          7020021010   70SP20030909  0    0  1225  1225   89%  02/12/2005    21:41 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm120          7020021010   70SP20030909  0    0   485   485   72%  02/12/2005    21:41 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm121          7020021010   70SP20030909  0    0   811   811   83%  02/12/2005    21:42 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
 vm122          7020021010   70SP20030909  0    0   422   422   68%  02/12/2005    21:42 INTEL_NT
INTEL_NT        QA70-1            COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm123             7020021010    70SP20030909  0    0   467   467   71%  02/12/2005    21:42 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm124             7020021010    70SP20030909  0    0   591   591   77%  02/12/2005    21:42 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm125             7020021010    70SP20030909  0    0   762   762   82%  02/12/2005    21:42 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm126             7020021010    70SP20030909  0    0   661   661   80%  02/12/2005    21:42 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm127             7020021010    70SP20030909  0    0   625   625   79%  02/12/2005    21:42 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm128             7020021010    70SP20030909  0    0   815   815   83%  02/12/2005    21:42 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm129             7020021010    70SP20030909  0    0   373   373   66%  02/12/2005    21:42 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm130             7020021010    70SP20030909  0    0   553   553   78%  02/12/2005    21:42 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm131             7020021010    70SP20030909  0    0   448   448   70%  02/12/2005    21:42 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm132             7020021010    70SP20030909  0    0  1827  1827   93%  02/12/2005    21:42 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm133             7020021010    70SP20030909  0    0  1701  1701   92%  02/12/2005    21:42 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm134             7020021010    70SP20030909  0    0  1808  1808   93%  02/12/2005    21:42 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm135             7020021010    70SP20030909  0    0   561   561   77%  02/12/2005    21:42 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm136             7020021010    70SP20030909  0    0  1909  1909   93%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm137             7020021010    70SP20030909  0    0  1395  1395   91%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm138             7020021010    70SP20030909  0    0   528   528   75%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm139             7020021010    70SP20030909  0    0  1132  1132   88%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm140             7020021010    70SP20030909  0    0  1184  1184   89%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm141             7020021010    70SP20030909  0    0  2040  2040   93%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm142             7020021010    70SP20030909  0    0   879   879   85%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm143             7020021010    70SP20030909  0    0  1672  1672   91%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm144             7020021010    70SP20030909  0     0  2164  2164   94%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm145             7020021010    70SP20030909  0     0   532   532   75%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm146             7020021010    70SP20030909  0     0   883   883   86%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm147             7020021010    70SP20030909  0     0   588   588   77%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm148             7020021010    70SP20030909  0     0   588   588   78%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm149             7020021010    70SP20030909  0     0   520   520   74%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm150             7020021010    70SP20030909  0     0   657   657   79%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm151             7020021010    70SP20030909  0     0  1058  1058   87%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm152             7020021010    70SP20030909  0     0  1211  1211   88%  02/12/2005    21:43 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm153             7020021010    70SP20030909  0     0   507   507   74%  02/12/2005    21:44 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm154             7020021010    70SP20030909  0     0   814   814   82%  02/12/2005    21:44 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm155             7020021010    70SP20030909  0     0  1255  1255   89%  02/12/2005    21:46 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm156             7020021010    70SP20030909  0     0  2047  2047   94%  02/12/2005    21:46 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm157             7020021010    70SP20030909  0     0   952   952   85%  02/12/2005    21:46 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm158             7020021010    70SP20030909  0     0   955   955   87%  02/12/2005    21:47 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm159             7020021010    70SP20030909  0     0  1524  1524   91%  02/12/2005    21:47 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm160             7020021010    70SP20030909  0     0   600   600   78%  02/12/2005    21:47 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm161             7020021010    70SP20030909  0     0   539   539   75%  02/12/2005    21:47 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm162             7020021010    70SP20030909  0     0   548   548   76%  02/12/2005    21:47 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm163             7020021010    70SP20030909  0     0   563   563   76%  02/12/2005    21:47 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm164             7020021010    70SP20030909  0     0   556   556   76%  02/12/2005    21:47 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm165              7020021010    70SP20030909   0     0   703   703   80%  02/12/2005    21:47 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm166              7020021010    70SP20030909   0     0   700   700   80%  02/12/2005    21:47 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm167              7020021010    70SP20030909   0     0  1138  1138   88%  02/12/2005    21:47 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm168              7020021010    70SP20030909   0     0   687   687   81%  02/12/2005    21:47 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm169              7020021010    70SP20030909   0     0   777   777   82%  02/12/2005    21:47 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm170              7020021010    70SP20030909   0     0   436   436   69%  02/12/2005    21:47 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm171              7020021010    70SP20030909   0     0   759   759   82%  02/12/2005    21:47 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm172              7020021010    70SP20030909   0     0  1528  1528   90%  02/12/2005    21:47 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm173              7020021010    70SP20030909   0     0   545   545   75%  02/12/2005    21:47 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm174              7020021010    70SP20030909   0     0   602   602   77%  02/12/2005    21:47 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm175              7020021010    70SP20030909   0     0   855   855   84%  02/12/2005    21:47 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm176              7020021010    70SP20030909   0     0   999   999   86%  02/12/2005    21:47 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm177              7020021010    70SP20030909   0     0  1127  1127   87%  02/12/2005    21:48 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm178              7020021010    70SP20030909   0     0   679   679   80%  02/12/2005    21:48 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm179              7020021010    70SP20030909   0     0   768   768   82%  02/12/2005    21:48 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm180              7020021010    70SP20030909   0     0   651   651   79%  02/12/2005    21:48 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm181              7020021010    70SP20030909   0     0   484   484   71%  02/12/2005    21:48 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm182              7020021010    70SP20030909   0     0   973   973   87%  02/12/2005    21:48 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm183              7020021010    70SP20030909   0     0   722   722   81%  02/12/2005    21:48 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm184              7020021010    70SP20030909   1     5  3162  3162   95%  02/12/2005    21:48 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
 vm185              7020021010    70SP20030909   0     0   738   738   81%  02/12/2005    21:48 INTEL_NT
INTEL_NT           QA70-1                COMPARE_REL 3.8 UP20020121 WINDOWS
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vm186	7020021010	70SP20030909	0	0	1392	1392	91%	02/12/2005	21:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm187	7020021010	70SP20030909	0	0	1489	1489	90%	02/12/2005	21:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm188	7020021010	70SP20030909	0	0	658	658	79%	02/12/2005	21:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm189	7020021010	70SP20030909	0	0	1067	1067	87%	02/12/2005	21:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm190	7020021010	70SP20030909	0	0	715	715	81%	02/12/2005	21:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm191	7020021010	70SP20030909	0	0	3075	3075	95%	02/12/2005	21:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm192	7020021010	70SP20030909	0	0	645	645	80%	02/12/2005	21:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm193	7020021010	70SP20030909	0	0	411	411	68%	02/12/2005	21:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm194	7020021010	70SP20030909	0	0	821	821	83%	02/12/2005	21:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm195	7020021010	70SP20030909	0	0	824	824	84%	02/12/2005	21:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm196	7020021010	70SP20030909	0	0	505	505	73%	02/12/2005	21:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm197	7020021010	70SP20030909	0	0	509	509	74%	02/12/2005	21:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm198	7020021010	70SP20030909	2	0	1208	1208	88%	02/12/2005	21:50	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm199	7020021010	70SP20030909	0	0	835	835	84%	02/12/2005	21:50	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm200	7020021010	70SP20030909	0	0	1258	1258	89%	02/12/2005	21:51	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm201	7020021010	70SP20030909	0	0	3072	3072	95%	02/12/2005	21:51	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm202	7020021010	70SP20030909	0	0	604	604	77%	02/12/2005	21:52	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm203	7020021010	70SP20030909	0	0	1020	1020	87%	02/12/2005	21:52	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm204	7020021010	70SP20030909	0	0	621	621	79%	02/12/2005	21:52	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm205	7020021010	70SP20030909	0	0	652	652	79%	02/12/2005	21:52	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm206	7020021010	70SP20030909	0	0	903	903	84%	02/12/2005	21:52	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS

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 vm207           7020021010   70SP20030909  0    0  1079  1079   87%  02/12/2005    21:52 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm208           7020021010   70SP20030909  0    0   701   701   82%  02/12/2005    21:52 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm209           7020021010   70SP20030909  0    0  3159  3159   96%  02/12/2005    21:53 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm210           7020021010   70SP20030909  0    0  1426  1426   90%  02/12/2005    21:53 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm211           7020021010   70SP20030909  0    0  2658  2658   94%  02/12/2005    21:55 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm212           7020021010   70SP20030909  0    0  1041  1041   86%  02/12/2005    21:55 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm213           7020021010   70SP20030909  0    0   687   687   80%  02/12/2005    21:55 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm214           7020021010   70SP20030909  0    0   557   557   76%  02/12/2005    21:55 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm215           7020021010   70SP20030909  0    0   637   637   80%  02/12/2005    21:55 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm216           7020021010   70SP20030909  0    0  1111  1111   87%  02/12/2005    21:55 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm217           7020021010   70SP20030909  0    0   873   873   84%  02/12/2005    21:56 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm218           7020021010   70SP20030909  0    0   744   744   82%  02/12/2005    21:56 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm219           7020021010   70SP20030909  0    0   698   698   81%  02/12/2005    21:56 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm220           7020021010   70SP20030909  0    0   477   477   75%  02/12/2005    21:57 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm221           7020021010   70SP20030909  0    0   605   605   80%  02/12/2005    21:57 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm222           7020021010   70SP20030909  0    0  1536  1536   91%  02/12/2005    21:57 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm223           7020021010   70SP20030909  0    0   484   484   74%  02/12/2005    21:57 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm224           7020021010   70SP20030909  0    0   577   577   79%  02/12/2005    21:57 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm225           7020021010   70SP20030909  0    0   496   496   73%  02/12/2005    21:57 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm226           7020021010   70SP20030909  0    0  1622  1622   91%  02/12/2005    21:58 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm227           7020021010   70SP20030909  0    0   957   957   87%  02/12/2005    21:58 INTEL_NT
INTEL_NT        QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm228            7020021010    70SP20030909   0    0  5849  5849   98%  02/12/2005    21:58 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm229            7020021010    70SP20030909   0    0  3944  3944   97%  02/12/2005    21:59 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm230            7020021010    70SP20030909   0    0 26798 26798   99%  02/12/2005    22:37 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm231            7020021010    70SP20030909   0    0   528   528   76%  02/12/2005    22:37 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm232            7020021010    70SP20030909   0    0 14057 14057   98%  02/12/2005    22:43 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm233            7020021010    70SP20030909   0    0   583   583   80%  02/12/2005    22:44 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm234            7020021010    70SP20030909   0    0  1468  1468   92%  02/12/2005    22:47 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm235            7020021010    70SP20030909   0    0   769   769   81%  02/12/2005    22:47 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm236            7020021010    70SP20030909   0    0  1760  1760   92%  02/12/2005    22:47 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc1             7020021010    70SP20030909   0    0   643   643   81%  02/12/2005    22:48 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc2             7020021010    70SP20030909   0    0  1692  1692   90%  02/12/2005    22:49 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc3             7020021010    70SP20030909   0    0   426   426   72%  02/12/2005    22:49 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc4             7020021010    70SP20030909   0    0   773   773   85%  02/12/2005    22:49 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc5             7020021010    70SP20030909   0    0   513   513   78%  02/12/2005    22:50 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc6             7020021010    70SP20030909   0    0   433   433   74%  02/12/2005    22:51 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc7             7020021010    70SP20030909   0    0   337   337   67%  02/12/2005    22:51 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc8             7020021010    70SP20030909   2    0  1894  1894   92%  02/12/2005    23:09 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmd1             7020021010    70SP20030909   0    0   816   816   86%  02/12/2005    23:09 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmd2             7020021010    70SP20030909   0    0   337   337   67%  02/12/2005    23:09 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vmd3             7020021010    70SP20030909   0    0   608   608   82%  02/12/2005    23:11 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 cyc-177s         7020021010    70SP20030909   1    0  1219  1222   91%  02/12/2005    23:13 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
```

cyc-178s	7020021010	70SP20030909	1	0	1219	1222	91%	02/12/2005	23:14	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
dds-13s	7020021010	NO_UPDATE	-88	0	402	146	49%	02/12/2005	23:14	INTEL_NT	NOT_AVAILABLE	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
dds-17s	7020021010	NO_UPDATE	-88	0	746	146	67%	02/12/2005	23:14	INTEL_NT	NOT_AVAILABLE	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
esp-112s	7020021010	70SP20030909	0	0	279	279	58%	02/12/2005	23:15	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
esp-124s	7020021010	70SP20030909	0	0	392	392	66%	02/12/2005	23:15	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
esp-127s	7020021010	70SP20030909	0	0	527	527	75%	02/12/2005	23:15	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ess-26s	7020021010	70SP20030909	0	0	1846	1846	92%	02/12/2005	23:15	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ess-97s	7020021010	70SP20030909	0	0	1378	1378	90%	02/12/2005	23:15	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev117-106s	7020021010	70SP20030909	0	0	1333	1333	91%	02/12/2005	23:15	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev119-35s	7020021010	70SP20030909	0	0	506	506	74%	02/12/2005	23:15	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev120-85s	7020021010	70SP20030909	0	0	411	411	71%	02/12/2005	23:15	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev141-208s	7020021010	70SP20030909	0	0	341	341	66%	02/12/2005	23:15	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev144-13s	7020021010	70SP20030909	0	8	8804	8804	98%	02/12/2005	23:17	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev144-23s	7020021010	70SP20030909	0	0	1740	1740	92%	02/12/2005	23:20	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev154-23s	7020021010	70SP20030909	0	0	1259	1259	89%	02/12/2005	23:20	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev154-25s	7020021010	70SP20030909	0	0	587	587	76%	02/12/2005	23:20	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev171-57s	7020021010	70SP20030909	0	0	542	542	79%	02/12/2005	23:20	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev173-53s	7020021010	70SP20030909	1	0	1426	1429	92%	02/12/2005	23:20	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev174-46s	7020021010	70SP20030909	0	0	562	562	80%	02/12/2005	23:20	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev175-20s	7020021010	70SP20030909	1	0	538	541	79%	02/12/2005	23:20	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev175-21s	7020021010	NO_UPDATE	-88	0	566	146	64%	02/12/2005	23:20	INTEL_NT	NOT_AVAILABLE	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS

ev175-38s	7020021010	70SP20030909	0	0	808	808	85%	02/12/2005	23:21	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev182-zbdpg11s	7020021010	70SP20030909	0	0	660	660	83%	02/12/2005	23:21	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev183-zdpl20s	7020021010	70SP20030909	0	0	577	577	80%	02/12/2005	23:21	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev184-02s	7020021010	70SP20030909	0	0	267	267	56%	02/12/2005	23:21	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev184-07s	7020021010	70SP20030909	0	0	661	661	80%	02/12/2005	23:21	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev35-23s	7020021010	70SP20030909	0	0	293	293	61%	02/12/2005	23:21	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev95-45s	7020021010	70SP20030909	0	0	892	892	85%	02/12/2005	23:21	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
ev97-73s	7020021010	70SP20030909	0	0	621	621	82%	02/12/2005	23:21	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
flo-136s	7020021010	70SP20030909	0	0	419	419	73%	02/12/2005	23:22	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
flo-138s	7020021010	70SP20030909	0	0	352	352	68%	02/12/2005	23:22	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
inrt-16s	7020021010	70SP20030909	1	0	484	486	77%	02/12/2005	23:22	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
inrt-9s	7020021010	70SP20030909	0	0	421	421	73%	02/12/2005	23:22	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
mvhy-bk501	7020021010	70SP20030909	0	0	536	536	78%	02/12/2005	23:23	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
mvhy-gt202	7020021010	70SP20030909	0	0	780	780	84%	02/12/2005	23:23	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
mvve-cr003	7020021010	70SP20030909	0	0	328	328	65%	02/12/2005	23:24	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
mvve-cr804	7020021010	70SP20030909	0	0	329	329	65%	02/12/2005	23:24	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
se-1s	7020021010	70SP20030909	0	0	400	400	72%	02/12/2005	23:24	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
se-20s	7020021010	70SP20030909	0	0	879	879	85%	02/12/2005	23:24	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
sx120-1s	7020021010	NO_UPDATE	-88	0	248	146	30%	02/12/2005	23:24	INTEL_NT	NOT_AVAILABLE	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
tbc-155s	7020021010	70SP20030909	0	0	351	351	64%	02/12/2005	23:24	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS

```
1

 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=c0231  10:37:04  OCT 15, 2002 CP=      0.219
 T= CURRENT JOBNAME=c0231  21:33:01  FEB 12, 2005 CP=      0.094

              0  /verify,c0231

              0  /title, c0231 (fsk) Unmatched nodes mapping

 COMPARE DIFFERENCE FOUND AT            NG=  192 NT=  192
 G=  NODAL RESULTS ARE FOR CYCLIC SECTOR   1 - PHASE ANGLE =     30.580
 T=  NODAL RESULTS ARE FOR CYCLIC SECTOR   1 - PHASE ANGLE =    237.330

 COMPARE DIFFERENCE FOUND AT            NG=  219 NT=  219
 G=  NODAL RESULTS ARE FOR CYCLIC SECTOR   2 - PHASE ANGLE =     30.580
 T=  NODAL RESULTS ARE FOR CYCLIC SECTOR   2 - PHASE ANGLE =    237.330

 COMPARE DIFFERENCE FOUND AT            NG=  246 NT=  246
 G=  NODAL RESULTS ARE FOR CYCLIC SECTOR   3 - PHASE ANGLE =     30.580
 T=  NODAL RESULTS ARE FOR CYCLIC SECTOR   3 - PHASE ANGLE =    237.330

 BOTTOM OF GOOD FILE REACHED AT LINE    289
 G= |                            ANSYS RUN COMPLETED                            |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       3                       *
 ************************************************


 ================================================================================
  PROBLEM: c0231            COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                 KNOWN  (# OF KNOWN ERRS)=   0
```

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                                              GREAD, TREAD =     1,    1
================================================================================

LINES ON GOOD FILE =       304
LINES ON TEST FILE =       304
****************************************************************************
```

```
1

 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=vm184  20:46:18  OCT 15, 2002 CP=      0.250
 T= CURRENT JOBNAME=vm184  21:48:44  FEB 12, 2005 CP=      0.109

               0  /VERIFY,VM184

               0  /TITLE, VM184, STRAIGHT CANTILEVER BEAM

               0  /stitle,1,Reason COMPARE differences are acceptable:

               0  /stitle,2,  mesher accuracy - element number on warning; near-
zero values

               0  /TITLE, VM184, STRAIGHT CANTILEVER BEAM

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 ABSOLUTE VALUE DIFFERENCE FOUND AT     NG=  926 NT=  926
 G= VALUE  -0.24849E-01 0.98917    -0.43496E-05 0.98948
 T= VALUE  -0.24849E-01 0.98917     0.43497E-05 0.98948

 ABSOLUTE VALUE DIFFERENCE FOUND AT     NG=  982 NT=  982
 G= VALUE  -0.53544E-02-0.26671E-05 0.42554     0.42557
 T= VALUE  -0.53544E-02 0.26671E-05 0.42554     0.42557

 ABSOLUTE VALUE DIFFERENCE FOUND AT     NG= 1011 NT= 1011
 G= VALUE  -0.12394E-01-0.61739E-05 0.98504     0.98511
 T= VALUE  -0.12394E-01 0.61739E-05 0.98504     0.98511

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 COMPARE DIFFERENCE FOUND AT            NG= 1580 NT= 1580
 G= VALUE   0.24811E-01 0.98813    -0.43696E-05 0.98844
 T= VALUE   0.24811E-01 0.98813     0.43701E-05 0.98844

 ABSOLUTE VALUE DIFFERENCE FOUND AT     NG= 1639 NT= 1639
 G= VALUE  -0.53533E-02-0.30755E-05 0.42553     0.42556
```

```
 T= VALUE  -0.53533E-02 0.30756E-05 0.42553     0.42556

 ABSOLUTE VALUE DIFFERENCE FOUND AT     NG= 1673 NT= 1673
 G= VALUE  -0.12392E-01-0.71193E-05 0.98502     0.98510
 T= VALUE  -0.12392E-01 0.71194E-05 0.98502     0.98510

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 BOTTOM OF GOOD FILE REACHED AT LINE   3147
 G= |                            ANSYS RUN COMPLETED                            |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************



 *****************************************************
 WARNING -      5 ABSOLUTE VALUE DIFFERENCE(S) FOUND.
 *****************************************************


 ************************************************************
 NOTE -   1 summary line(s) contained absolute value differences.
 ************************************************************

 ================================================================================
  PROBLEM: vm184            COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004              MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE   = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                 KNOWN  (# OF KNOWN ERRS)=   0
```

```
                                                      GREAD, TREAD =     1,    1
================================================================================

LINES ON GOOD FILE =      3162
LINES ON TEST FILE =      3162
*****************************************************************************
```

```
1

 ****************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=vm198  20:50:49  OCT 15, 2002 CP=      0.266
 T= CURRENT JOBNAME=vm198  21:49:55  FEB 12, 2005 CP=      0.094

              0  /VERIFY,VM198

              0  /TITLE, VM198, LARGE STRAIN IN-PLANE TORSION TEST (%EL%)

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 COMPARE DIFFERENCE FOUND AT            NG=  618 NT=  618
 G= RELEASE  0.0      UPDATE        0   CUSTOMER  00000000
 T= RELEASE  0.0      UPDATE        0   CUSTOMER  00292062

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 COMPARE DIFFERENCE FOUND AT            NG=  907 NT=  907
 G= RELEASE  0.0      UPDATE        0   CUSTOMER  00000000
 T= RELEASE  0.0      UPDATE        0   CUSTOMER  00292062

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****
```

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BOTTOM OF GOOD FILE REACHED AT LINE   1193
G= |                            ANSYS RUN COMPLETED                                       |



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NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

***********************************************
COMPARE ERRORS =       2                      *
***********************************************


================================================================================
 PROBLEM: vm198            COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

ALMOST ZERO (GOOD)    = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
ALMOST ZERO (TEST)    = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
ABSOLUTE VALUE TOL    = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                               KNOWN  (# OF KNOWN ERRS)=   0
                                               GREAD, TREAD =    1,   1
================================================================================

LINES ON GOOD FILE =      1208
LINES ON TEST FILE =      1208
*****************************************************************************
```

```
1

 ******************************************************************************

  00000000         VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=vmc8  21:52:06  OCT 15, 2002 CP=      0.219
 T= CURRENT JOBNAME=vmc8  22:51:25  FEB 12, 2005 CP=      0.125

               0  /VERIFY,VMC8

               0  /TITLE, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY

               0  /stitle,1,Reason COMPARE differences are acceptable:

               0  /stitle,2,  number of iterations, accuracy

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
PLANE2

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
PLANE42

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
PLANE82

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
VISCO106

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
SOLID45

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
SOLID95

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
VISCO107

               0  /TITLE, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 COMPARE DIFFERENCE FOUND AT            NG=  880 NT=  880
 G= SET COMMAND GOT LOAD STEP=     2  SUBSTEP=   320  CUMULATIVE ITERATION=  3255
 T= SET COMMAND GOT LOAD STEP=     2  SUBSTEP=   320  CUMULATIVE ITERATION=  3240
```

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 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****

 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****

 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****

 COMPARE DIFFERENCE FOUND AT            NG= 1227 NT= 1227
 G=   3 ESOL     1 EPPL EQV  EPPLEQV   0.7401E-16  0.000      3.410      0.000
 T=   3 ESOL     1 EPPL EQV  EPPLEQV   0.2694E-35  0.000      3.422      0.000

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****

 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****

 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****
```

```
 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 BOTTOM OF GOOD FILE REACHED AT LINE   1879
 G= |                               ANSYS RUN COMPLETED                              |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       2                       *
 ************************************************


 ================================================================================
  PROBLEM: vmc8             COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)   = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)   = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL   = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004            MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006            MAXBUF (# LINES TO SCAN)=   6
                                               KNOWN  (# OF KNOWN ERRS)=   0
                                               GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =      1894
 LINES ON TEST FILE =      1894
 *****************************************************************************
```

```
1

 ****************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=cyc-177s  11:45:34  OCT 15, 2002 CP=      0.219
 T= CURRENT JOBNAME=cyc-177s  23:11:09  FEB 12, 2005 CP=      0.109

              0  /verify,cyc-177s

              0  /TITLE, ceb,cyc-177s, Test cyc symm Buckling element 42

              0  /title,1,Full Results to Sector Results!

              0  /stitle,Reason Compare differences are acceptable:

 EXTRA DATA SKIPPED ON TEST FILE        NG= 1202 NT= 1194
 T= USE COMMAND MACRO QAEND
 T= ARGS=   289.00
 END OF SKIPPED DATA                    NG= 1202 NT= 1199

 BOTTOM OF GOOD FILE REACHED AT LINE   1204
 G= |                            ANSYS RUN COMPLETED                            |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************


 ================================================================================
  PROBLEM: cyc-177s         COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)   = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)   = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL   = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
                                                GREAD, TREAD =    1,   1
 ================================================================================
```

```
LINES ON GOOD FILE =      1219
LINES ON TEST FILE =      1222
******************************************************************************
```

```
1

 ****************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=cyc-178s  11:48:41  OCT 15, 2002 CP=      0.250
 T= CURRENT JOBNAME=cyc-178s  23:13:04  FEB 12, 2005 CP=      0.125

              0  /verify,cyc-178s

              0  /TITLE, ceb,cyc-178s, Test cyc symm Buckling element 182

              0  /title,1,Full Results to Sector Results!

              0  /stitle,Reason Compare differences are acceptable:

 EXTRA DATA SKIPPED ON TEST FILE        NG= 1202 NT= 1194
 T= USE COMMAND MACRO QAEND
 T= ARGS=   289.00
 END OF SKIPPED DATA                    NG= 1202 NT= 1199

 BOTTOM OF GOOD FILE REACHED AT LINE   1204
 G= |                            ANSYS RUN COMPLETED                            |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************


 ================================================================================
  PROBLEM: cyc-178s         COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006           KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006           KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010           KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004            MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE   = 1.0000E-006           MAXBUF (# LINES TO SCAN)=   6
                                               KNOWN  (# OF KNOWN ERRS)=   0
                                               GREAD, TREAD =    1,   1
 ================================================================================
```

```
LINES ON GOOD FILE =      1219
LINES ON TEST FILE =      1222
*****************************************************************************
```

```
1
 ******************************************************************************


   *** ERROR -- (VERSION=) was not found anywhere in the  "TEST" file.       ***
   *** Comparison was supposed to start at this string, specified in CMPOPT. ***


 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =     -88                       *
 ************************************************


 ================================================================================
  PROBLEM: dds-13s          COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
                                                GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =      402
 LINES ON TEST FILE =      146
 ******************************************************************************
```

```
1
 ****************************************************************************


   *** ERROR -- (VERSION=) was not found anywhere in the  "TEST" file.       ***
   *** Comparison was supposed to start at this string, specified in CMPOPT. ***


 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ***********************************************
 COMPARE ERRORS =     -88                      *
 ***********************************************


 ===============================================================================
  PROBLEM: dds-17s          COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
                                                GREAD, TREAD =    1,   1
 ===============================================================================

 LINES ON GOOD FILE =      746
 LINES ON TEST FILE =      146
 ****************************************************************************
```

```
1
 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=ev173-53s  14:02:31  OCT 15, 2002 CP=      0.234
 T= CURRENT JOBNAME=ev173-53s  23:20:30  FEB 12, 2005 CP=      0.094

              0  /verify,ev173-53s

              0  /title,ev173-53s,mfquresh,Test to verify PSOVLE,ELFORM for 171-
175 (3D) with PENE

 EXTRA DATA SKIPPED ON TEST FILE        NG= 1409 NT= 1401
 T= USE COMMAND MACRO QAEND
 T= ARGS=   20.000
 END OF SKIPPED DATA                    NG= 1409 NT= 1406

 BOTTOM OF GOOD FILE REACHED AT LINE   1411
 G= |                           ANSYS RUN COMPLETED                           |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************


 ================================================================================
  PROBLEM: ev173-53s        COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)   = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)   = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL   = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
                                                GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =      1426
 LINES ON TEST FILE =      1429
 ******************************************************************************
```

```
1
 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=ev175-20s  14:22:03  OCT 15, 2002 CP=      0.250
 T= CURRENT JOBNAME=ev175-20s  23:20:55  FEB 12, 2005 CP=      0.094

              0  /verify,ev175-20s

              0  /title,ev175-20s,mfq, Check real constant FKN and FTOLN and
KEYOPT(2)=0,1

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 EXTRA DATA SKIPPED ON TEST FILE        NG=  521 NT=  513
 T= USE COMMAND MACRO QAEND
 T= ARGS=   3.0000
 END OF SKIPPED DATA                    NG=  521 NT=  518

 BOTTOM OF GOOD FILE REACHED AT LINE    523
 G= |                            ANSYS RUN COMPLETED                            |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************


 ================================================================================
  PROBLEM: ev175-20s        COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE   = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                 KNOWN  (# OF KNOWN ERRS)=   0
                                                 GREAD, TREAD =    1,   1
 ================================================================================
```

```
LINES ON GOOD FILE =      538
LINES ON TEST FILE =      541
*****************************************************************************
```

```
1
 ******************************************************************************

   *** ERROR -- (VERSION=) was not found anywhere in the  "TEST" file.       ***
   *** Comparison was supposed to start at this string, specified in CMPOPT. ***

 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =     -88                       *
 ************************************************

 ================================================================================
  PROBLEM: ev175-21s        COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
                                                GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =      566
 LINES ON TEST FILE =      146
 ******************************************************************************
```

```
1

 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=inrt-16s  16:14:59  OCT 15, 2002 CP=      0.219
 T= CURRENT JOBNAME=inrt-16s  23:22:50  FEB 12, 2005 CP=      0.109

               0  /VERIFY,INRT-16S

               0  /TITLE, INRT-16S, ceb, component omega loading and layer
elements

               0  /TITLE, INRT-16S, BENDING OF A COMPOSITE BEAM

 EXTRA DATA SKIPPED ON TEST FILE        NG=  462 NT=  459
 T= USE COMMAND MACRO QAEND
 END OF SKIPPED DATA                    NG=  462 NT=  463

 BOTTOM OF GOOD FILE REACHED AT LINE    469
 G= |                            ANSYS RUN COMPLETED                            |


 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     1
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     1
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************
```

```
1
 ****************************************************************************

   *** ERROR -- (VERSION=) was not found anywhere in the  "TEST" file.       ***
   *** Comparison was supposed to start at this string, specified in CMPOPT. ***

 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =     -88                       *
 ************************************************

 ===============================================================================
  PROBLEM: sx120-1s         COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)   = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)   = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL   = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
                                                GREAD, TREAD =    1,   1
 ===============================================================================

 LINES ON GOOD FILE =      248
 LINES ON TEST FILE =      146
 ****************************************************************************
```

Software Acceptance

1) Project Title and Number: DST Thermal and Seismic Analyses 48971

2) Software Name and Version: ANSYS 7.0 (Rev. 11)

3) Computer and Property Number: Generic PC WD44903

4) Operating System: Windows XP Professional Version 2002 Service Pack 2

4) Scope of Testing: Hardware replacement and Software reinstallation (XP SP2)

5) Tests: Execute ANSYS Verification Testing Package

6) Discrepancies:

aa) c0231. These differences are acceptable per the ANSYS Verification Package User's Guide – ANSYS Release 7.0 (AVPUG).
bb) vm33. These differences are acceptable due to the unused degree of freedom (see AVPUG).
cc) vm176. These differences are acceptable due to the unused degree of freedom (see AVPUG).
dd) vm184. These differences occur at the 5th significant figure.
ee) vm198. This difference is the reporting of the customer number for this installation.
ff) vmc8. These differences are acceptable as noted in the output because of the difference in number of iterations and accuracy.
gg) cyc-177s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).
hh) cyc-178s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).
ii) dds-13s. This test case requires the "Parallel Performance Module" which is not part of this software installation and is not required for the DST analyses.
jj) dds-17s. This test case requires the "Parallel Performance Module" which is not part of this software installation and is not required for the DST analyses.
kk) ev173-53s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).
ll) ev175-20s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).
mm) ev175-21s. This test case requires the "Parallel Performance Module" which is not part of this software installation and is not required for the DST analyses.
nn) inrt-16s. This difference is acceptable due to the handling of the QAEND macro (see AVPUG).

7) Finding: This installation of ANSYS is acceptable

Certified by:

JE Deibler John E Deibler 11/11/05
Code Custodian

Reviewed by:

SP Pilli Siva prasad.P 02/03/06.
Staff Engineer

12/1 0/2002 Page 1 of 1 Addendum to ANSYS Verification Testing Package User's Guide -ANSYS Release 7.0

Notes for test case cO231

Test case cO231 may show considerable differences for the Phase Angle value that is part of the Post1 Nodal Degree of Freedom Listing (PRNS command) output. Any such differences do not indicate a problem with this test case's results and should be considered acceptable. The output items of significance for this test case are the UZ values in the Post1 Nodal Degree of Freedom Listing. Machine precision differences in the form of small numerical differences that are trivial with respect to the test's output items of significance may also show for this test case in the compare output for this test. Please see **Verifying ANSYS and Evaluating COMPARE Differences** in Chapter 2 of the *ANSYS Verification Testing Package User's Guide* for more information on evaluating COMPARE differences. The following is an example of acceptable COMPARE differences for test case cO231 :

COMPARE DIFFERENCE FOUND AT G= NODAL RESULTS ARE FOR CYCLIC SECTOR T= NODAL RESULTS ARE FOR CYCLIC SECTOR

COMPARE DIFFERENCE FOUND AT G= VALUE -9.8117 -3.7700 22. T= VALUE -9.8119 -3.7693 22.

COMPARE DIFFERENCE FOUND AT G= NODAL RESULTS ARE FOR CYCLIC SECTOR T= NODAL RESULTS ARE FOR CYCLIC SECTOR

COMPARE DIFFERENCE FOUND AT G= VALUE -9.7579 -3.9649 22. T= VALUE -9.7581 -3.9643 22.

COMPARE DIFFERENCE FOUND AT G= NODAL RESULTS ARE FOR CYCLIC SECTOR T= NODAL RESULTS ARE FOR CYCLIC SECTOR

COMPARE DIFFERENCE FOUWAT --~-*c;;;i';;* G= 8 0.53291 0.39425 io T= 8 0.53293 *p.39419* 10

COMPARE DIFFERENCE FOUND AT G= 10 0.52495 0.39568 9. T= 10 0.52497 0.39562 9.

COMPARE DIFFERENCE FOUND AT NG= 259 NT= 259 G= 12 0.50433 0.40282 8.6482 8.6722 T= 12 0.50435 0.40276 8.6471 8.6711

COMPARE DIFFERENCE FOUND AT NG= 260 NT= 260 G= 14 0.48186 0.41201 7.8710 7.8965 T= 14 0.48188 0.41196 7.8700 7.8955

COMPARE DIFFERENCE FOUND AT NG= 261 NT= 261 G= 16 0.45505 0.42478 7.0719 7.0992 T= 16 0.45507 0.42473 7.0710 7.0983

COMPARE DIFFERENCE FOUND AT NG= 262 NT= 262 G= 18 0.42339 0.44092 6.2424 6.2723 T= 18 0.42341 0.44086 6.2417 6.2715

COMPARE DIFFERENCE FOUND AT NG= 263 NT= 263 G= 20 0.38501 0.46124 5.3732 5.4067 T= 20 0.38502 0.46118 5.3726 5.4061

COMPARE DIFFERENCE FOUND AT NG= 267 NT= 267 G= VALUE -9.6034 -3.9649 18.806 21.413 T= VALUE -9.6036 -3.9643 18.805 21.412

NG= 271 NT= 271 22.469 24.766 22.469 24.766

NG= 192 NT= 192 1 -PHASE ANGLE = 1- **PHASE ANGLE** =

NG= 213 NT= 213 469 24.766 469 24.766

NG= 219 NT= 219 2- PHASE ANGLE = 2- **PHASE ANGLE** =

NG= 240 NT= 240 440 24.710 440 24.710

NG= 246 NT= 246 3- PHASE ANGLE = 3 **-PHASE ANGLE** =

NG-= **257** ***m-~-257 .161 10.183 .160 10.181***

NG= 4080 4068

258 NT= 258 9.4309 9.4297

COMPARE DIFFERENCE FOUND **AT G= VALUE -9.8117 -3.9649 T= VALUE -9.8119 -3.9643**

30.580 306.570

30.580 306.570

30.580 306.570

Notes for Test Case vm33 and vm176

Test case vm33 and vm176 will produce a number of expected compare differences due to product restrictions in the PLANE13 element's functionality. The expected compare differences are the result of the MAG degree of freedom being absent in the test case's output when it is run with the ANSYS/ Mechanical product. Since the MAG degree of freedom is unused in these test cases, these compare differences should be considered acceptable.

Notes for Test Case vrn212

Test case vm212 may produce an expected compare difference due to an inconsequential warning message that appears in the ANSYS, Inc. supplied output file that may not appear in the output file generated by your system for this test case. This compare difference should be considered acceptable. The following is an example of this compare difference.

```
 COMPARE DIFFERENCE FOUND AT              NG= 445 NT= 436
 G= NUMBER OF WARNING MESSAGES ENCOUNTERED= 1
 T= NUMBER OF WARNING MESSAGES ENCOUNTERED= 0
```

Notes for Test Cases cyc-177s, cyc-178s, ev-173-53s, ev-175-20s, inrt-16s, and inrt-9s

Test cases cyc-177s, cyc-178s, ev-173-53s, ev-175-20s, inrt-16s, and inrt-9s may produce expected compare differences due to the use of a macro named qaend. The method that is used in the verification procudure (runqa) to handle this macro may cause one or more comparison differences. Any such compare differences are inconsequential and should be considered acceptable. The following is an example of such a compare difference.

```
EXTRA DATA SKIPPED ON TEST FILE          NG= 1033 NT= 1030
T= USE COMMAND MACRO qaend
T= ARGS= 137.00
END OF SKIPPED DATA                      NG= 1033 NT= 1033
```

Notes for test Cases dds-13s, dds-17s, and ev175-21 s

The test cases dds-13s, dds-17s, and ev175-21 s will run to completion only if the "Parallel Performance for ANSYS" product (DDS and AMG solvers) is included in your ANSYS installation.

c0211r2 7020021010 70SP20030909 0 0 605 605 81% 11/10/2005 17:25 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0212 7020021010 70SP20030909 0 0 223 223 45% 11/10/2005 17:26 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0213 7020021010 70SP20030909 0 0 197 197 41% 11/10/2005 17:26 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0214 7020021010 70SP20030909 0 0 409 409 67% 11/10/2005 17:26 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0215 7020021010 70SP20030909 0 0 648 648 81% 11/10/2005 17:26 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0216 7020021010 70SP20030909 0 0 510 510 74% 11/10/2005 17:26 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0218 7020021010 70SP20030909 0 0 1627 1627 93% 11/10/2005 17:26 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0219 7020021010 70SP20030909 0 0 2732 2732 95% 11/10/2005 17:26 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0220 7020021010 70SP20030909 0 0 494 494 76% 11/10/2005 17:26 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0221 7020021010 70SP20030909 0 0 1265 1265 90% 11/10/2005 17:26 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0222 7020021010 70SP20030909 0 0 1543 1543 92% 11/10/2005 17:27 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0223 7020021010 70SP20030909 0 0 362 362 66% 11/10/2005 17:27 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0224 7020021010 70SP20030909 0 0 307 307 59% 11/10/2005 17:27 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0225 7020021010 70SP20030909 0 0 420 420 70% 11/10/2005 17:27 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0226 7020021010 70SP20030909 0 0 521 521 74% 11/10/2005 17:27 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0227 7020021010 70SP20030909 0 0 380 380 65% 11/10/2005 17:28 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0227a 7020021010 70SP20030909 0 0 380 380 65% 11/10/2005 17:28 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0228 7020021010 70SP20030909 0 0 236 236 50% 11/10/2005 17:28 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0229 7020021010 70SP20030909 0 0 715 715 81% 11/10/2005 17:28 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0230 7020021010 70SP20030909 0 0 2513 2513 94% 11/10/2005 17:28 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS
c0231 7020021010 70SP20030909 3 0 304 304 61% 11/10/2005 17:28 INTEL_NT
INTEL_NT QA70-1 COMPARE_REL 3.8 UP20020121 WINDOWS

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 c0232            7020021010    70SP20030909  0    0   517   517   79%  11/10/2005    17:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0233            7020021010    70SP20030909  0    0   542   542   75%  11/10/2005    17:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 c0234            7020021010    70SP20030909  0    0   420   420   68%  11/10/2005    17:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm1              7020021010    70SP20030909  0    0   474   474   72%  11/10/2005    17:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm2              7020021010    70SP20030909  0    0   667   667   81%  11/10/2005    17:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm3              7020021010    70SP20030909  0    0   499   499   73%  11/10/2005    17:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm4              7020021010    70SP20030909  0    0   434   434   69%  11/10/2005    17:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm5              7020021010    70SP20030909  0    0   884   884   85%  11/10/2005    17:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm6              7020021010    70SP20030909  0    0   854   854   83%  11/10/2005    17:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm7              7020021010    70SP20030909  0    0  2176  2176   93%  11/10/2005    17:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm8              7020021010    70SP20030909  0    0   346   346   64%  11/10/2005    17:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm9              7020021010    70SP20030909  0    0   851   851   85%  11/10/2005    17:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm10             7020021010    70SP20030909  0    0   437   437   69%  11/10/2005    17:29 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm11             7020021010    70SP20030909  0    0   885   885   85%  11/10/2005    17:30 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm12             7020021010    70SP20030909  0    0   444   444   70%  11/10/2005    17:30 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm13             7020021010    70SP20030909  0    0   464   464   71%  11/10/2005    17:30 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm14             7020021010    70SP20030909  0    0   537   537   76%  11/10/2005    17:30 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm15             7020021010    70SP20030909  0    0  1356  1356   91%  11/10/2005    17:30 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm16             7020021010    70SP20030909  0    0   740   740   82%  11/10/2005    17:30 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm17             7020021010    70SP20030909  0    0   546   546   76%  11/10/2005    17:30 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm18             7020021010    70SP20030909  0    0   450   450   71%  11/10/2005    17:30 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm19            7020021010   70SP20030909  0    0   725   725   80%  11/10/2005    17:30 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm20            7020021010   70SP20030909  0    0   449   449   70%  11/10/2005    17:30 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm21            7020021010   70SP20030909  0    0   805   805   82%  11/10/2005    17:30 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm22            7020021010   70SP20030909  0    0   398   398   66%  11/10/2005    17:30 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm23            7020021010   70SP20030909  0    0  1043  1043   88%  11/10/2005    17:30 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm24            7020021010   70SP20030909  0    0   766   766   82%  11/10/2005    17:31 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm25            7020021010   70SP20030909  0    0  2350  2350   95%  11/10/2005    17:31 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm26            7020021010   70SP20030909  0    0  1829  1829   89%  11/10/2005    17:31 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm27            7020021010   70SP20030909  0    0   910   910   85%  11/10/2005    17:31 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm28            7020021010   70SP20030909  0    0   418   418   70%  11/10/2005    17:31 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm29            7020021010   70SP20030909  0    0   683   683   80%  11/10/2005    17:31 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm30            7020021010   70SP20030909  0    0   449   449   70%  11/10/2005    17:31 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm31            7020021010   70SP20030909  0    0   551   551   76%  11/10/2005    17:31 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm32            7020021010   70SP20030909  0    0   881   881   84%  11/10/2005    17:31 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm33            7020021010   70SP20030909  6    0   902   896   85%  11/10/2005    17:31 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm34            7020021010   70SP20030909  0    0  1380  1380   90%  11/10/2005    17:31 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm35            7020021010   70SP20030909  0    0   594   594   77%  11/10/2005    17:32 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm36            7020021010   70SP20030909  0    0  1086  1086   88%  11/10/2005    17:32 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm37            7020021010   70SP20030909  0    0   690   690   81%  11/10/2005    17:32 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm38            7020021010   70SP20030909  0    0  1667  1667   92%  11/10/2005    17:32 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
 vm39            7020021010   70SP20030909  0    0   819   819   84%  11/10/2005    17:32 INTEL_NT
INTEL_NT         QA70-1             COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm40              7020021010    70SP20030909   0     0   876   876   86%  11/10/2005    17:32 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm41              7020021010    70SP20030909   0     0   829   829   83%  11/10/2005    17:32 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm42              7020021010    70SP20030909   0     0   607   607   77%  11/10/2005    17:32 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm43              7020021010    70SP20030909   0     0   860   860   85%  11/10/2005    17:32 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm44              7020021010    70SP20030909   0     0  1198  1198   90%  11/10/2005    17:32 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm45              7020021010    70SP20030909   0     0   416   416   67%  11/10/2005    17:32 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm47              7020021010    70SP20030909   0     0   416   416   67%  11/10/2005    17:32 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm48              7020021010    70SP20030909   0     0   421   421   68%  11/10/2005    17:32 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm50              7020021010    70SP20030909   0     0   500   500   72%  11/10/2005    17:32 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm52              7020021010    70SP20030909   0     0   520   520   74%  11/10/2005    17:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm53              7020021010    70SP20030909   0     0   789   789   82%  11/10/2005    17:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm54              7020021010    70SP20030909   0     0   564   564   75%  11/10/2005    17:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm55              7020021010    70SP20030909   0     0   995   995   87%  11/10/2005    17:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm56              7020021010    70SP20030909   0     0  1577  1577   91%  11/10/2005    17:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm57              7020021010    70SP20030909   0     0   737   737   81%  11/10/2005    17:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm58              7020021010    70SP20030909   0     0   580   580   76%  11/10/2005    17:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm59              7020021010    70SP20030909   0     0   833   833   84%  11/10/2005    17:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm60              7020021010    70SP20030909   0     0   537   537   72%  11/10/2005    17:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm61              7020021010    70SP20030909   0     0   402   402   66%  11/10/2005    17:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm62              7020021010    70SP20030909   0     0   755   755   82%  11/10/2005    17:33 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vm63              7020021010    70SP20030909   0     0  1280  1280   89%  11/10/2005    17:34 INTEL_NT
INTEL_NT          QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
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vm64	7020021010	70SP20030909	0	0	510	510	74%	11/10/2005	17:34	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm65	7020021010	70SP20030909	0	0	3323	3323	96%	11/10/2005	17:34	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm66	7020021010	70SP20030909	0	0	516	516	74%	11/10/2005	17:34	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm67	7020021010	70SP20030909	0	0	591	591	76%	11/10/2005	17:34	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm68	7020021010	70SP20030909	0	0	739	739	80%	11/10/2005	17:34	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm69	7020021010	70SP20030909	0	0	553	553	75%	11/10/2005	17:34	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm70	7020021010	70SP20030909	0	0	940	940	86%	11/10/2005	17:34	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm71	7020021010	70SP20030909	0	0	1307	1307	87%	11/10/2005	17:34	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm72	7020021010	70SP20030909	0	0	2161	2161	90%	11/10/2005	17:34	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm73	7020021010	70SP20030909	0	0	4189	4189	97%	11/10/2005	17:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm74	7020021010	70SP20030909	0	0	855	855	81%	11/10/2005	17:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm75	7020021010	70SP20030909	0	0	1129	1129	84%	11/10/2005	17:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm76	7020021010	70SP20030909	0	0	1187	1187	89%	11/10/2005	17:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm77	7020021010	70SP20030909	0	0	876	876	82%	11/10/2005	17:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm78	7020021010	70SP20030909	0	0	872	872	86%	11/10/2005	17:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm79	7020021010	70SP20030909	0	0	954	954	83%	11/10/2005	17:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm80	7020021010	70SP20030909	0	0	2205	2205	92%	11/10/2005	17:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm81	7020021010	70SP20030909	0	0	2015	2015	93%	11/10/2005	17:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm82	7020021010	70SP20030909	0	0	2144	2144	94%	11/10/2005	17:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm83	7020021010	70SP20030909	0	0	2191	2191	94%	11/10/2005	17:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm84	7020021010	70SP20030909	0	0	821	821	82%	11/10/2005	17:35	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS

vm85	7020021010	70SP20030909	0	0	858	858	84%	11/10/2005	17:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm86	7020021010	70SP20030909	0	0	428	428	68%	11/10/2005	17:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm87	7020021010	70SP20030909	0	0	434	434	69%	11/10/2005	17:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm88	7020021010	70SP20030909	0	0	450	450	70%	11/10/2005	17:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm89	7020021010	70SP20030909	0	0	480	480	72%	11/10/2005	17:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm90	7020021010	70SP20030909	0	0	761	761	82%	11/10/2005	17:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm91	7020021010	70SP20030909	0	0	2102	2102	94%	11/10/2005	17:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm92	7020021010	70SP20030909	0	0	501	501	73%	11/10/2005	17:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm93	7020021010	70SP20030909	0	0	436	436	69%	11/10/2005	17:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm94	7020021010	70SP20030909	0	0	508	508	73%	11/10/2005	17:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm95	7020021010	70SP20030909	0	0	1044	1044	86%	11/10/2005	17:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm96	7020021010	70SP20030909	0	0	633	633	78%	11/10/2005	17:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm97	7020021010	70SP20030909	0	0	809	809	83%	11/10/2005	17:36	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm98	7020021010	70SP20030909	0	0	703	703	80%	11/10/2005	17:37	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm99	7020021010	70SP20030909	0	0	482	482	72%	11/10/2005	17:37	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm100	7020021010	70SP20030909	0	0	642	642	79%	11/10/2005	17:37	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm101	7020021010	70SP20030909	0	0	720	720	81%	11/10/2005	17:37	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm102	7020021010	70SP20030909	0	0	761	761	82%	11/10/2005	17:37	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm103	7020021010	70SP20030909	0	0	782	782	84%	11/10/2005	17:37	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm104	7020021010	70SP20030909	0	0	1822	1822	93%	11/10/2005	17:37	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm105	7020021010	70SP20030909	0	0	589	589	77%	11/10/2005	17:37	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS

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 vm106            7020021010    70SP20030909   0    0   432   432   69%  11/10/2005    17:37 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm107            7020021010    70SP20030909   0    0   476   476   72%  11/10/2005    17:37 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm108            7020021010    70SP20030909   0    0   437   437   69%  11/10/2005    17:37 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm109            7020021010    70SP20030909   0    0  1025  1025   87%  11/10/2005    17:37 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm110            7020021010    70SP20030909   0    0   743   743   82%  11/10/2005    17:38 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm111            7020021010    70SP20030909   0    0  3511  3511   96%  11/10/2005    17:38 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm112            7020021010    70SP20030909   0    0   726   726   81%  11/10/2005    17:38 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm113            7020021010    70SP20030909   0    0   732   732   82%  11/10/2005    17:38 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm114            7020021010    70SP20030909   0    0   693   693   80%  11/10/2005    17:38 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm115            7020021010    70SP20030909   0    0   604   604   78%  11/10/2005    17:38 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm116            7020021010    70SP20030909   0    0   830   830   84%  11/10/2005    17:38 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm118            7020021010    70SP20030909   0    0   918   918   85%  11/10/2005    17:38 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm119            7020021010    70SP20030909   0    0  1225  1225   89%  11/10/2005    17:38 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm122            7020021010    70SP20030909   0    0   422   422   68%  11/10/2005    17:38 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm123            7020021010    70SP20030909   0    0   467   467   71%  11/10/2005    17:38 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm124            7020021010    70SP20030909   0    0   591   591   77%  11/10/2005    17:39 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm125            7020021010    70SP20030909   0    0   762   762   82%  11/10/2005    17:39 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm126            7020021010    70SP20030909   0    0   661   661   80%  11/10/2005    17:39 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm127            7020021010    70SP20030909   0    0   625   625   79%  11/10/2005    17:39 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm128            7020021010    70SP20030909   0    0   815   815   83%  11/10/2005    17:39 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm129            7020021010    70SP20030909   0    0   373   373   66%  11/10/2005    17:39 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
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vm130	7020021010	70SP20030909	0	0	553	553	78%	11/10/2005	17:39	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm131	7020021010	70SP20030909	0	0	448	448	70%	11/10/2005	17:39	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm132	7020021010	70SP20030909	0	0	1827	1827	93%	11/10/2005	17:39	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm133	7020021010	70SP20030909	0	0	1701	1701	92%	11/10/2005	17:39	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm134	7020021010	70SP20030909	0	0	1808	1808	93%	11/10/2005	17:39	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm135	7020021010	70SP20030909	0	0	561	561	77%	11/10/2005	17:39	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm136	7020021010	70SP20030909	0	0	1909	1909	93%	11/10/2005	17:40	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm137	7020021010	70SP20030909	0	0	1395	1395	91%	11/10/2005	17:40	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm138	7020021010	70SP20030909	0	0	528	528	75%	11/10/2005	17:40	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm139	7020021010	70SP20030909	0	0	1132	1132	88%	11/10/2005	17:40	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm140	7020021010	70SP20030909	0	0	1184	1184	89%	11/10/2005	17:40	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm141	7020021010	70SP20030909	0	0	2040	2040	93%	11/10/2005	17:40	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm142	7020021010	70SP20030909	0	0	879	879	85%	11/10/2005	17:40	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm143	7020021010	70SP20030909	0	0	1672	1672	91%	11/10/2005	17:40	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm144	7020021010	70SP20030909	0	0	2164	2164	94%	11/10/2005	17:40	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm145	7020021010	70SP20030909	0	0	532	532	75%	11/10/2005	17:40	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm146	7020021010	70SP20030909	0	0	883	883	86%	11/10/2005	17:40	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm147	7020021010	70SP20030909	0	0	588	588	77%	11/10/2005	17:40	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm148	7020021010	70SP20030909	0	0	588	588	78%	11/10/2005	17:41	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm149	7020021010	70SP20030909	0	0	520	520	74%	11/10/2005	17:41	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm150	7020021010	70SP20030909	0	0	657	657	79%	11/10/2005	17:41	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS

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 vm151              7020021010    70SP20030909   0    0  1058  1058   87%  11/10/2005    17:41 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm152              7020021010    70SP20030909   0    0  1211  1211   88%  11/10/2005    17:41 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm153              7020021010    70SP20030909   0    0   507   507   74%  11/10/2005    17:41 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm154              7020021010    70SP20030909   0    0   814   814   82%  11/10/2005    17:41 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm155              7020021010    70SP20030909   0    0  1255  1255   89%  11/10/2005    17:42 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm156              7020021010    70SP20030909   0    0  2047  2047   94%  11/10/2005    17:42 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm157              7020021010    70SP20030909   0    0   952   952   85%  11/10/2005    17:42 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm158              7020021010    70SP20030909   0    0   955   955   87%  11/10/2005    17:42 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm159              7020021010    70SP20030909   0    0  1524  1524   91%  11/10/2005    17:42 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm160              7020021010    70SP20030909   0    0   600   600   78%  11/10/2005    17:42 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm161              7020021010    70SP20030909   0    0   539   539   75%  11/10/2005    17:42 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm162              7020021010    70SP20030909   0    0   548   548   76%  11/10/2005    17:43 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm163              7020021010    70SP20030909   0    0   563   563   76%  11/10/2005    17:43 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm164              7020021010    70SP20030909   0    0   556   556   76%  11/10/2005    17:43 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm170              7020021010    70SP20030909   0    0   436   436   69%  11/10/2005    17:43 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm171              7020021010    70SP20030909   0    0   759   759   82%  11/10/2005    17:43 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm173              7020021010    70SP20030909   0    0   545   545   75%  11/10/2005    17:43 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm174              7020021010    70SP20030909   0    0   602   602   77%  11/10/2005    17:43 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm175              7020021010    70SP20030909   0    0   855   855   84%  11/10/2005    17:43 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm176              7020021010    70SP20030909  22    0   999   970   86%  11/10/2005    17:43 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm177              7020021010    70SP20030909   0    0  1127  1127   87%  11/10/2005    17:43 INTEL_NT
INTEL_NT            QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
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 vm179              7020021010    70SP20030909   0     0   768   768   82%  11/10/2005    17:44 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm180              7020021010    70SP20030909   0     0   651   651   79%  11/10/2005    17:44 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm181              7020021010    70SP20030909   0     0   484   484   71%  11/10/2005    17:44 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm182              7020021010    70SP20030909   0     0   973   973   87%  11/10/2005    17:44 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm183              7020021010    70SP20030909   0     0   722   722   81%  11/10/2005    17:44 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm184              7020021010    70SP20030909   1     5  3162  3162   95%  11/10/2005    17:44 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm187              7020021010    70SP20030909   0     0  1489  1489   90%  11/10/2005    17:44 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm191              7020021010    70SP20030909   0     0  3075  3075   95%  11/10/2005    17:44 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm192              7020021010    70SP20030909   0     0   645   645   80%  11/10/2005    17:44 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm193              7020021010    70SP20030909   0     0   411   411   68%  11/10/2005    17:45 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm194              7020021010    70SP20030909   0     0   821   821   83%  11/10/2005    17:45 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm195              7020021010    70SP20030909   0     0   824   824   84%  11/10/2005    17:45 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm196              7020021010    70SP20030909   0     0   505   505   73%  11/10/2005    17:45 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm197              7020021010    70SP20030909   0     0   509   509   74%  11/10/2005    17:45 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm198              7020021010    70SP20030909   2     0  1208  1208   88%  11/10/2005    17:45 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm199              7020021010    70SP20030909   0     0   835   835   84%  11/10/2005    17:45 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm200              7020021010    70SP20030909   0     0  1258  1258   89%  11/10/2005    17:47 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm201              7020021010    70SP20030909   0     0  3072  3072   95%  11/10/2005    17:47 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm202              7020021010    70SP20030909   0     0   604   604   77%  11/10/2005    17:47 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm203              7020021010    70SP20030909   0     0  1020  1020   87%  11/10/2005    17:47 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 vm204              7020021010    70SP20030909   0     0   621   621   79%  11/10/2005    17:47 INTEL_NT
INTEL_NT           QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
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vm205	7020021010	70SP20030909	0	0	652	652	79%	11/10/2005	17:47	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm210	7020021010	70SP20030909	0	0	1426	1426	90%	11/10/2005	17:47	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm211	7020021010	70SP20030909	0	0	2658	2658	94%	11/10/2005	17:48	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm215	7020021010	70SP20030909	0	0	637	637	80%	11/10/2005	17:48	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm216	7020021010	70SP20030909	0	0	1111	1111	87%	11/10/2005	17:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm217	7020021010	70SP20030909	0	0	873	873	84%	11/10/2005	17:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm218	7020021010	70SP20030909	0	0	744	744	82%	11/10/2005	17:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm222	7020021010	70SP20030909	0	0	1536	1536	91%	11/10/2005	17:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm224	7020021010	70SP20030909	0	0	577	577	79%	11/10/2005	17:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm225	7020021010	70SP20030909	0	0	496	496	73%	11/10/2005	17:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm227	7020021010	70SP20030909	0	0	957	957	87%	11/10/2005	17:49	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm228	7020021010	70SP20030909	0	0	5849	5849	98%	11/10/2005	17:50	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm229	7020021010	70SP20030909	0	0	3944	3944	97%	11/10/2005	17:53	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm230	7020021010	70SP20030909	0	0	26798	26798	99%	11/10/2005	17:54	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm231	7020021010	70SP20030909	0	0	528	528	76%	11/10/2005	17:54	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm232	7020021010	70SP20030909	0	0	14057	14057	98%	11/10/2005	17:56	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vm234	7020021010	70SP20030909	0	0	1468	1468	92%	11/10/2005	17:57	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vmc1	7020021010	70SP20030909	0	0	643	643	81%	11/10/2005	17:58	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vmc2	7020021010	70SP20030909	0	0	1692	1692	90%	11/10/2005	17:58	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vmc3	7020021010	70SP20030909	0	0	426	426	72%	11/10/2005	17:58	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS
vmc4	7020021010	70SP20030909	0	0	773	773	85%	11/10/2005	17:58	INTEL_NT	INTEL_NT	QA70-1	COMPARE_REL	3.8	UP20020121	WINDOWS

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 vmc5           7020021010   70SP20030909   0    0   513   513   78%  11/10/2005    17:59 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc6           7020021010   70SP20030909   0    0   433   433   74%  11/10/2005    17:59 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc7           7020021010   70SP20030909   0    0   337   337   67%  11/10/2005    17:59 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vmc8           7020021010   70SP20030909   2    0  1894  1894   92%  11/10/2005    18:28 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vmd1           7020021010   70SP20030909   0    0   816   816   86%  11/10/2005    18:28 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vmd2           7020021010   70SP20030909   0    0   337   337   67%  11/10/2005    18:28 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 vmd3           7020021010   70SP20030909   0    0   608   608   82%  11/10/2005    18:28 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 cyc-177s       7020021010   70SP20030909   1    0  1219  1222   91%  11/10/2005    18:29 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 cyc-178s       7020021010   70SP20030909   1    0  1219  1222   91%  11/10/2005    18:30 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 dds-13s        7020021010   NO_UPDATE    -88    0   402   146   49%  11/10/2005    18:30 INTEL_NT
NOT_AVAILABLE   QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 dds-17s        7020021010   NO_UPDATE    -88    0   746   146   67%  11/10/2005    18:30 INTEL_NT
NOT_AVAILABLE   QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 esp-112s       7020021010   70SP20030909   0    0   279   279   58%  11/10/2005    18:30 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 esp-124s       7020021010   70SP20030909   0    0   392   392   66%  11/10/2005    18:30 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 esp-127s       7020021010   70SP20030909   0    0   527   527   75%  11/10/2005    18:30 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ess-26s        7020021010   70SP20030909   0    0  1846  1846   92%  11/10/2005    18:30 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ess-97s        7020021010   70SP20030909   0    0  1378  1378   90%  11/10/2005    18:30 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev154-23s      7020021010   70SP20030909   0    0  1259  1259   89%  11/10/2005    18:30 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev154-25s      7020021010   70SP20030909   0    0   587   587   76%  11/10/2005    18:31 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev171-57s      7020021010   70SP20030909   0    0   542   542   79%  11/10/2005    18:31 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev173-53s      7020021010   70SP20030909   1    0  1426  1429   92%  11/10/2005    18:31 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
 ev175-20s      7020021010   70SP20030909   1    0   538   541   79%  11/10/2005    18:31 INTEL_NT
INTEL_NT        QA70-1              COMPARE_REL 3.8 UP20020121 WINDOWS
```

```
 ev175-21s        7020021010    NO_UPDATE    -88    0   566   146   64%  11/10/2005    18:31 INTEL_NT
NOT_AVAILABLE    QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 ev175-38s        7020021010    70SP20030909  0     0   808   808   85%  11/10/2005    18:31 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 ev182-zbdpg11s   7020021010    70SP20030909  0     0   660   660   83%  11/10/2005    18:31 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 ev183-zdpl20s    7020021010    70SP20030909  0     0   577   577   80%  11/10/2005    18:32 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 ev184-02s        7020021010    70SP20030909  0     0   267   267   56%  11/10/2005    18:32 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 ev184-07s        7020021010    70SP20030909  0     0   661   661   80%  11/10/2005    18:32 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 ev35-23s         7020021010    70SP20030909  0     0   293   293   61%  11/10/2005    18:32 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 ev95-45s         7020021010    70SP20030909  0     0   892   892   85%  11/10/2005    18:32 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 inrt-16s         7020021010    70SP20030909  1     0   484   486   77%  11/10/2005    18:32 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 inrt-9s          7020021010    70SP20030909  0     0   421   421   73%  11/10/2005    18:32 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 mvhy-bk501       7020021010    70SP20030909  0     0   536   536   78%  11/10/2005    18:32 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 mvhy-gt202       7020021010    70SP20030909  0     0   780   780   84%  11/10/2005    18:32 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 mvve-cr003       7020021010    70SP20030909  0     0   328   328   65%  11/10/2005    18:33 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 mvve-cr804       7020021010    70SP20030909  0     0   329   329   65%  11/10/2005    18:33 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 se-1s            7020021010    70SP20030909  0     0   400   400   72%  11/10/2005    18:33 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
 se-20s           7020021010    70SP20030909  0     0   879   879   85%  11/10/2005    18:33 INTEL_NT
INTEL_NT         QA70-1               COMPARE_REL 3.8 UP20020121 WINDOWS
```

```
1

 ****************************************************************************

  00000000         VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
G= CURRENT JOBNAME=c0231  10:37:04  OCT 15, 2002 CP=      0.219
 T= CURRENT JOBNAME=c0231  17:28:23  NOV 10, 2005 CP=      0.375

              0  /verify,c0231

              0  /title, c0231 (fsk) Unmatched nodes mapping

 COMPARE DIFFERENCE FOUND AT            NG=  192 NT=  192
 G=  NODAL RESULTS ARE FOR CYCLIC SECTOR   1 - PHASE ANGLE =     30.580
 T=  NODAL RESULTS ARE FOR CYCLIC SECTOR   1 - PHASE ANGLE =    237.330

 COMPARE DIFFERENCE FOUND AT            NG=  219 NT=  219
 G=  NODAL RESULTS ARE FOR CYCLIC SECTOR   2 - PHASE ANGLE =     30.580
 T=  NODAL RESULTS ARE FOR CYCLIC SECTOR   2 - PHASE ANGLE =    237.330

 COMPARE DIFFERENCE FOUND AT            NG=  246 NT=  246
 G=  NODAL RESULTS ARE FOR CYCLIC SECTOR   3 - PHASE ANGLE =     30.580
 T=  NODAL RESULTS ARE FOR CYCLIC SECTOR   3 - PHASE ANGLE =    237.330

 BOTTOM OF GOOD FILE REACHED AT LINE    289
 G= |                            ANSYS RUN COMPLETED                              |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       3                       *
 ************************************************


 ================================================================================
  PROBLEM: c0231           COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
```

```
                                             GREAD, TREAD =     1,    1
===============================================================================

LINES ON GOOD FILE =      304
LINES ON TEST FILE =      304
****************************************************************************
```

```
1

 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=vm33  20:03:05  OCT 15, 2002 CP=      0.219
 T= CURRENT JOBNAME=vm33  17:31:47  NOV 10, 2005 CP=      0.375

              0  /VERIFY,VM33

              0  /TITLE, VM33, TRANSIENT THERMAL STRESS IN A CYLINDER

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 COMPARE DIFFERENCE FOUND AT            NG=  236 NT=  236
 G= CURRENT NODAL DOF SET IS  UX    UY    UZ    TEMP  VOLT  MAG
 T= CURRENT NODAL DOF SET IS  UX    UY    UZ    TEMP  VOLT

 COMPARE DIFFERENCE FOUND AT            NG=  419 NT=  419
 G=   DEGREES OF FREEDOM. . . . . . UX   UY   UZ   TEMP VOLT MAG
 T=   DEGREES OF FREEDOM. . . . . . UX   UY   UZ   TEMP VOLT

 EXTRA DATA SKIPPED ON GOOD FILE        NG=  422 NT=  425
 G=   ELECTRO-MAGNETIC UNITS. . . . . . . . . . . . .MKS
 G=      MUZERO . . . . . . . . . . . . . . . . . . . . 0.12566E-05
 END OF SKIPPED DATA                    NG=  424 NT=  425

 EXTRA DATA SKIPPED ON GOOD FILE        NG=  427 NT=  428
 G= Element 1 references undefined MURX or BH table for material 1.
 G= *** WARNING ***                         CP=      0.000   TIME= 00:00:00
 END OF SKIPPED DATA                    NG=  430 NT=  428

 EXTRA DATA SKIPPED ON GOOD FILE        NG=  453 NT=  449
 G=      MAGNETIC DOFS. . . . . . . . . . . . . . . . .    ON
 END OF SKIPPED DATA                    NG=  454 NT=  449

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 COMPARE DIFFERENCE FOUND AT            NG=  881 NT=  875
 G= NUMBER OF WARNING MESSAGES ENCOUNTERED=          4
 T= NUMBER OF WARNING MESSAGES ENCOUNTERED=          3

 BOTTOM OF GOOD FILE REACHED AT LINE    887
 G= |                           ANSYS RUN COMPLETED                            |
```

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NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

************************************************
COMPARE ERRORS =       6                       *
************************************************


================================================================================
 PROBLEM: vm33             COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

ALMOST ZERO (GOOD)   = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
ALMOST ZERO (TEST)   = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
ABSOLUTE VALUE TOL   = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
FRACTIONAL DIFFERENCE= 1.0000E-004            MAXERR (STOP WHEN ERRS )= 100
ABSOLUTE DIFFERENCE  = 1.0000E-006            MAXBUF (# LINES TO SCAN)=   6
                                              KNOWN  (# OF KNOWN ERRS)=   0
                                              GREAD, TREAD =    1,   1
================================================================================

LINES ON GOOD FILE =      902
LINES ON TEST FILE =      896
*****************************************************************************
```

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1

 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=vm176  20:43:52  OCT 15, 2002 CP=      0.234
 T= CURRENT JOBNAME=vm176  17:43:39  NOV 10, 2005 CP=      0.375

              0  /VERIFY,VM176

              0  /TITLE, VM176, FREQUENCY RESPONSE OF ELECTRICAL INPUT
ADMITTANCE FOR A

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 COMPARE DIFFERENCE FOUND AT            NG=  276 NT=  276
 G= CURRENT NODAL DOF SET IS  UX    UY    UZ    TEMP  VOLT  MAG
 T= CURRENT NODAL DOF SET IS  UX    UY    UZ    TEMP  VOLT

 COMPARE DIFFERENCE FOUND AT            NG=  617 NT=  617
 G=   DEGREES OF FREEDOM. . . . . . UX   UY   UZ   TEMP VOLT MAG
 T=   DEGREES OF FREEDOM. . . . . . UX   UY   UZ   TEMP VOLT

 EXTRA DATA SKIPPED ON GOOD FILE        NG=  623 NT=  627
 G=   ELECTRO-MAGNETIC UNITS. . . . . . . . . . . . .MKS
 G=      MUZERO . . . . . . . . . . . . . . . . . . . 0.12566E-05
 END OF SKIPPED DATA                    NG=  626 NT=  627

 COMPARE DIFFERENCE FOUND AT            NG=  627 NT=  625
 G= Element 1 references undefined MURX or BH table for material 3.
 T= Element 1 references undefined KXX for material 3.

 EXTRA DATA SKIPPED ON GOOD FILE        NG=  630 NT=  630
 G= Element 1 references undefined KXX for material 3.
 G= *** WARNING ***                         CP=      0.000   TIME= 00:00:00
 END OF SKIPPED DATA                    NG=  633 NT=  630

 COMPARE DIFFERENCE FOUND AT            NG=  638 NT=  633
 G= Element 11 references undefined MURX or BH table for material 4.
 T= Element 11 references undefined KXX for material 4.

 COMPARE DIFFERENCE FOUND AT            NG=  641 NT=  636
 G= Element 11 references undefined KXX for material 4.
 T= Element 11 references undefined RSVX or PERX for material 4.

 COMPARE DIFFERENCE FOUND AT            NG=  644 NT=  639
 G= Element 11 references undefined RSVX or PERX for material 4.
 T= Element 16 references undefined KXX for material 2.

 EXTRA DATA SKIPPED ON GOOD FILE        NG=  647 NT=  648
```

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G= Element 16 references undefined MURX or BH table for material 2.
G= *** WARNING ***                          CP=      0.000   TIME= 00:00:00
G= Element 16 references undefined KXX for material 2.
G= *** WARNING ***                          CP=      0.000   TIME= 00:00:00
END OF SKIPPED DATA                     NG=  653 NT=  648

COMPARE DIFFERENCE FOUND AT             NG=  731 NT=  720
G= Element 1 references undefined MURX or BH table for material 3.
T= Element 1 references undefined KXX for material 3.

EXTRA DATA SKIPPED ON GOOD FILE         NG=  734 NT=  725
G= Element 1 references undefined KXX for material 3.
G= *** WARNING ***                          CP=      0.000   TIME= 00:00:00
END OF SKIPPED DATA                     NG=  737 NT=  725

COMPARE DIFFERENCE FOUND AT             NG=  742 NT=  728
G= Element 11 references undefined MURX or BH table for material 4.
T= Element 11 references undefined KXX for material 4.

COMPARE DIFFERENCE FOUND AT             NG=  745 NT=  731
G= Element 11 references undefined KXX for material 4.
T= Element 11 references undefined RSVX or PERX for material 4.

COMPARE DIFFERENCE FOUND AT             NG=  748 NT=  734
G= Element 11 references undefined RSVX or PERX for material 4.
T= Element 16 references undefined KXX for material 2.

EXTRA DATA SKIPPED ON GOOD FILE         NG=  751 NT=  742
G= Element 16 references undefined MURX or BH table for material 2.
G= *** WARNING ***                          CP=      0.000   TIME= 00:00:00
G= Element 16 references undefined KXX for material 2.
G= *** WARNING ***                          CP=      0.000   TIME= 00:00:00
END OF SKIPPED DATA                     NG=  757 NT=  742

COMPARE DIFFERENCE FOUND AT             NG=  784 NT=  764
G= Element 1 references undefined MURX or BH table for material 3.
T= Element 1 references undefined KXX for material 3.

EXTRA DATA SKIPPED ON GOOD FILE         NG=  787 NT=  769
G= Element 1 references undefined KXX for material 3.
G= *** WARNING ***                          CP=      0.000   TIME= 00:00:00
END OF SKIPPED DATA                     NG=  790 NT=  769

COMPARE DIFFERENCE FOUND AT             NG=  795 NT=  772
G= Element 11 references undefined MURX or BH table for material 4.
T= Element 11 references undefined KXX for material 4.

COMPARE DIFFERENCE FOUND AT             NG=  798 NT=  775
G= Element 11 references undefined KXX for material 4.
T= Element 11 references undefined RSVX or PERX for material 4.

COMPARE DIFFERENCE FOUND AT             NG=  801 NT=  778
G= Element 11 references undefined RSVX or PERX for material 4.
T= Element 16 references undefined KXX for material 2.

EXTRA DATA SKIPPED ON GOOD FILE         NG=  804 NT=  786
G= Element 16 references undefined MURX or BH table for material 2.
```

```
G= *** WARNING ***                        CP=      0.000   TIME= 00:00:00
G= Element 16 references undefined KXX for material 2.
G= *** WARNING ***                        CP=      0.000   TIME= 00:00:00
END OF SKIPPED DATA                  NG=  810 NT=  786

NOW COMPARING LINES FROM         ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


COMPARE DIFFERENCE FOUND AT            NG=  978 NT=  949
G= NUMBER OF WARNING MESSAGES ENCOUNTERED=         32
T= NUMBER OF WARNING MESSAGES ENCOUNTERED=         23

BOTTOM OF GOOD FILE REACHED AT LINE    984
G= |                            ANSYS RUN COMPLETED                           |



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NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

************************************************
COMPARE ERRORS =      22                       *
************************************************


================================================================================
 PROBLEM: vm176            COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

ALMOST ZERO (GOOD)   = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
ALMOST ZERO (TEST)   = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
ABSOLUTE VALUE TOL   = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                               KNOWN  (# OF KNOWN ERRS)=   0
                                               GREAD, TREAD =    1,   1
================================================================================

LINES ON GOOD FILE =      999
LINES ON TEST FILE =      970
*****************************************************************************
```

```
1

 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=vm184  20:46:18  OCT 15, 2002 CP=      0.250
 T= CURRENT JOBNAME=vm184  17:44:26  NOV 10, 2005 CP=      0.375

               0  /VERIFY,VM184

               0  /TITLE, VM184, STRAIGHT CANTILEVER BEAM

               0  /stitle,1,Reason COMPARE differences are acceptable:

               0  /stitle,2,  mesher accuracy - element number on warning; near-
zero values

               0  /TITLE, VM184, STRAIGHT CANTILEVER BEAM

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 ABSOLUTE VALUE DIFFERENCE FOUND AT     NG=  926 NT=  926
 G= VALUE  -0.24849E-01 0.98917    -0.43496E-05 0.98948
 T= VALUE  -0.24849E-01 0.98917     0.43497E-05 0.98948

 ABSOLUTE VALUE DIFFERENCE FOUND AT     NG=  982 NT=  982
 G= VALUE  -0.53544E-02-0.26671E-05 0.42554     0.42557
 T= VALUE  -0.53544E-02 0.26671E-05 0.42554     0.42557

 ABSOLUTE VALUE DIFFERENCE FOUND AT     NG= 1011 NT= 1011
 G= VALUE  -0.12394E-01-0.61739E-05 0.98504     0.98511
 T= VALUE  -0.12394E-01 0.61739E-05 0.98504     0.98511

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 COMPARE DIFFERENCE FOUND AT            NG= 1580 NT= 1580
 G= VALUE   0.24811E-01 0.98813    -0.43696E-05 0.98844
 T= VALUE   0.24811E-01 0.98813     0.43701E-05 0.98844

 ABSOLUTE VALUE DIFFERENCE FOUND AT     NG= 1639 NT= 1639
 G= VALUE  -0.53533E-02-0.30755E-05 0.42553     0.42556
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```
T= VALUE  -0.53533E-02 0.30756E-05 0.42553     0.42556

ABSOLUTE VALUE DIFFERENCE FOUND AT     NG= 1673 NT= 1673
G= VALUE  -0.12392E-01-0.71193E-05 0.98502     0.98510
T= VALUE  -0.12392E-01 0.71194E-05 0.98502     0.98510

NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


BOTTOM OF GOOD FILE REACHED AT LINE   3147
G= |                            ANSYS RUN COMPLETED                            |



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NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

************************************************
COMPARE ERRORS =       1                       *
************************************************



*****************************************************
WARNING -      5 ABSOLUTE VALUE DIFFERENCE(S) FOUND.
*****************************************************


************************************************************
NOTE -   1 summary line(s) contained absolute value differences.
************************************************************

================================================================================
 PROBLEM: vm184           COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

ALMOST ZERO (GOOD)    = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
ALMOST ZERO (TEST)    = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
ABSOLUTE VALUE TOL    = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
ABSOLUTE DIFFERENCE   = 1.0000E-006            MAXBUF (# LINES TO SCAN)=   6
                                               KNOWN  (# OF KNOWN ERRS)=   0
```

```
                                                            GREAD, TREAD =     1,    1
================================================================================

LINES ON GOOD FILE =      3162
LINES ON TEST FILE =      3162
****************************************************************************
```

```
1

 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=vm198  20:50:49  OCT 15, 2002 CP=      0.266
 T= CURRENT JOBNAME=vm198  17:45:25  NOV 10, 2005 CP=      0.344

              0  /VERIFY,VM198

              0  /TITLE, VM198, LARGE STRAIN IN-PLANE TORSION TEST (%EL%)

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 COMPARE DIFFERENCE FOUND AT            NG=  618 NT=  618
 G= RELEASE  0.0      UPDATE        0   CUSTOMER  00000000
 T= RELEASE  0.0      UPDATE        0   CUSTOMER  00292062

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 COMPARE DIFFERENCE FOUND AT            NG=  907 NT=  907
 G= RELEASE  0.0      UPDATE        0   CUSTOMER  00000000
 T= RELEASE  0.0      UPDATE        0   CUSTOMER  00292062

 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****
```

```
BOTTOM OF GOOD FILE REACHED AT LINE   1193
G= |                               ANSYS RUN COMPLETED                                 |



~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

************************************************
COMPARE ERRORS =       2                       *
************************************************


================================================================================
 PROBLEM: vm198            COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

ALMOST ZERO (GOOD)   = 1.0000E-006           KROUND (DROP LAST DIGIT)=   1
ALMOST ZERO (TEST)   = 1.0000E-006           KABSPR (0=SUMMARY 1=ALL)=   1
ABSOLUTE VALUE TOL   = 1.0000E-010           KSKIP(SKIP=ERR 0=Y, 1=N)=   0
FRACTIONAL DIFFERENCE= 1.0000E-004           MAXERR (STOP WHEN ERRS )= 100
ABSOLUTE DIFFERENCE  = 1.0000E-006           MAXBUF (# LINES TO SCAN)=   6
                                             KNOWN  (# OF KNOWN ERRS)=   0
                                             GREAD, TREAD =    1,   1
================================================================================

LINES ON GOOD FILE =     1208
LINES ON TEST FILE =     1208
*****************************************************************************
```

```
1

 ****************************************************************************

  00000000         VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=vmc8  21:52:06  OCT 15, 2002 CP=      0.219
 T= CURRENT JOBNAME=vmc8  17:59:57  NOV 10, 2005 CP=      0.375

               0  /VERIFY,VMC8

               0  /TITLE, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY

               0  /stitle,1,Reason COMPARE differences are acceptable:

               0  /stitle,2,  number of iterations, accuracy

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
PLANE2

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
PLANE42

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
PLANE82

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
VISCO106

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
SOLID45

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
SOLID95

               0    /title, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY -
VISCO107

               0  /TITLE, VMC8, ALUMINUM BAR IMPACTING A RIGID BOUNDARY

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 COMPARE DIFFERENCE FOUND AT            NG=  880 NT=  880
 G= SET COMMAND GOT LOAD STEP=     2  SUBSTEP=   320  CUMULATIVE ITERATION=  3255
 T= SET COMMAND GOT LOAD STEP=     2  SUBSTEP=   320  CUMULATIVE ITERATION=  3240
```

```
 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 COMPARE DIFFERENCE FOUND AT            NG= 1227 NT= 1227
 G=   3 ESOL     1 EPPL EQV  EPPLEQV   0.7401E-16  0.000      3.410      0.000
 T=   3 ESOL     1 EPPL EQV  EPPLEQV   0.2694E-35  0.000      3.422      0.000

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****


 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 NOW COMPARING LINES FROM          ***** ANSYS RESULTS INTERPRETATION (POST1)
*****
```

```
 NOW COMPARING LINES FROM          ***** TIME-HISTORY POSTPROCESSOR (POST26)
*****


 BOTTOM OF GOOD FILE REACHED AT LINE   1879
 G= |                              ANSYS RUN COMPLETED                                  |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ***********************************************
 COMPARE ERRORS =       2                       *
 ***********************************************


 ===============================================================================
  PROBLEM: vmc8             COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)   = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)   = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL   = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004            MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006            MAXBUF (# LINES TO SCAN)=   6
                                               KNOWN  (# OF KNOWN ERRS)=   0
                                               GREAD, TREAD =    1,   1
 ===============================================================================

 LINES ON GOOD FILE =     1894
 LINES ON TEST FILE =     1894
 ****************************************************************************
```

```
1

 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=cyc-177s  11:45:34  OCT 15, 2002 CP=      0.219
 T= CURRENT JOBNAME=cyc-177s  18:28:58  NOV 10, 2005 CP=      0.359

              0  /verify,cyc-177s

              0  /TITLE, ceb,cyc-177s, Test cyc symm Buckling element 42

              0  /title,1,Full Results to Sector Results!

              0  /stitle,Reason Compare differences are acceptable:

 EXTRA DATA SKIPPED ON TEST FILE        NG= 1202 NT= 1194
 T= USE COMMAND MACRO QAEND
 T= ARGS=   289.00
 END OF SKIPPED DATA                    NG= 1202 NT= 1199

 BOTTOM OF GOOD FILE REACHED AT LINE   1204
 G= |                            ANSYS RUN COMPLETED                           |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************


 ================================================================================
  PROBLEM: cyc-177s         COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)   = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)   = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL   = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004            MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006            MAXBUF (# LINES TO SCAN)=   6
                                               KNOWN  (# OF KNOWN ERRS)=   0
                                               GREAD, TREAD =    1,   1
 ================================================================================
```

```
LINES ON GOOD FILE =     1219
LINES ON TEST FILE =     1222
******************************************************************************
```

```
1

 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=cyc-178s  11:48:41  OCT 15, 2002 CP=      0.250
 T= CURRENT JOBNAME=cyc-178s  18:29:39  NOV 10, 2005 CP=      0.359

               0  /verify,cyc-178s

               0  /TITLE, ceb,cyc-178s, Test cyc symm Buckling element 182

               0  /title,1,Full Results to Sector Results!

               0  /stitle,Reason Compare differences are acceptable:

 EXTRA DATA SKIPPED ON TEST FILE        NG= 1202 NT= 1194
 T= USE COMMAND MACRO QAEND
 T= ARGS=   289.00
 END OF SKIPPED DATA                    NG= 1202 NT= 1199

 BOTTOM OF GOOD FILE REACHED AT LINE   1204
 G= |                            ANSYS RUN COMPLETED                           |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************


 ================================================================================
  PROBLEM: cyc-178s         COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004              MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006              MAXBUF (# LINES TO SCAN)=   6
                                                 KNOWN  (# OF KNOWN ERRS)=   0
                                                 GREAD, TREAD =    1,   1
 ================================================================================
```

```
LINES ON GOOD FILE =     1219
LINES ON TEST FILE =     1222
****************************************************************************
```

```
1

 ******************************************************************************


   *** ERROR -- (VERSION=) was not found anywhere in the  "TEST" file.       ***
   *** Comparison was supposed to start at this string, specified in CMPOPT. ***


 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =     -88                       *
 ************************************************


 ================================================================================
  PROBLEM: dds-13s          COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
                                                GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =      402
 LINES ON TEST FILE =      146
 ******************************************************************************
```

```
1

 *****************************************************************************


   *** ERROR -- (VERSION=) was not found anywhere in the  "TEST" file.       ***
   *** Comparison was supposed to start at this string, specified in CMPOPT. ***


 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =     -88                       *
 ************************************************


 ================================================================================
  PROBLEM: dds-17s          COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006             KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006             KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010             KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004              MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006              MAXBUF (# LINES TO SCAN)=   6
                                                 KNOWN  (# OF KNOWN ERRS)=   0
                                                 GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =      746
 LINES ON TEST FILE =      146
 *****************************************************************************
```

```
1
 ***************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=ev173-53s  14:02:31  OCT 15, 2002 CP=      0.234
 T= CURRENT JOBNAME=ev173-53s  18:31:16  NOV 10, 2005 CP=      0.406

              0  /verify,ev173-53s

              0  /title,ev173-53s,mfquresh,Test to verify PSOVLE,ELFORM for 171-
175 (3D) with PENE

 EXTRA DATA SKIPPED ON TEST FILE        NG= 1409 NT= 1401
 T= USE COMMAND MACRO QAEND
 T= ARGS=   20.000
 END OF SKIPPED DATA                    NG= 1409 NT= 1406

 BOTTOM OF GOOD FILE REACHED AT LINE   1411
 G= |                           ANSYS RUN COMPLETED                              |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************


 ================================================================================
  PROBLEM: ev173-53s        COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)   = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)   = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL   = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004            MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006            MAXBUF (# LINES TO SCAN)=   6
                                               KNOWN  (# OF KNOWN ERRS)=   0
                                               GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =     1426
 LINES ON TEST FILE =     1429
 ***************************************************************************
```

```
1

 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=ev175-20s  14:22:03  OCT 15, 2002 CP=      0.250
 T= CURRENT JOBNAME=ev175-20s  18:31:34  NOV 10, 2005 CP=      0.328

              0  /verify,ev175-20s

              0  /title,ev175-20s,mfq, Check real constant FKN and FTOLN and
KEYOPT(2)=0,1

 NOW COMPARING LINES FROM          ***** ANSYS ANALYSIS DEFINITION (PREP7) *****


 EXTRA DATA SKIPPED ON TEST FILE        NG=  521 NT=  513
 T= USE COMMAND MACRO QAEND
 T= ARGS=   3.0000
 END OF SKIPPED DATA                    NG=  521 NT=  518

 BOTTOM OF GOOD FILE REACHED AT LINE    523
 G= |                            ANSYS RUN COMPLETED                           |



 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     2
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                      *
 ************************************************


 ================================================================================
  PROBLEM: ev175-20s       COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE   = 1.0000E-006            MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
                                                GREAD, TREAD =    1,   1
 ================================================================================
```

```
LINES ON GOOD FILE =      538
LINES ON TEST FILE =      541
******************************************************************************
```

```
1

 ****************************************************************************

   *** ERROR -- (VERSION=) was not found anywhere in the  "TEST" file.       ***
   *** Comparison was supposed to start at this string, specified in CMPOPT. ***

 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     0
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =     -88                       *
 ************************************************


 ================================================================================
  PROBLEM: ev175-21s        COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)    = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)    = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL    = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004             MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006             MAXBUF (# LINES TO SCAN)=   6
                                                KNOWN  (# OF KNOWN ERRS)=   0
                                                GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =      566
 LINES ON TEST FILE =      146
 ****************************************************************************
```

```
1
 ******************************************************************************

  00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  113 NT=  113
 G= 00000000          VERSION=INTEL NT        RELEASE= 7.0     UP20021010
 T= 00292062          VERSION=INTEL NT        RELEASE= 7.0SP11 UP20030909

 EXPECTED COMPARE DIFFERENCE FOUND AT   NG=  114 NT=  114
 G= CURRENT JOBNAME=inrt-16s  16:14:59  OCT 15, 2002 CP=      0.219
 T= CURRENT JOBNAME=inrt-16s  18:32:29  NOV 10, 2005 CP=      0.391

              0  /VERIFY,INRT-16S

              0  /TITLE, INRT-16S, ceb, component omega loading and layer
elements

              0  /TITLE, INRT-16S, BENDING OF A COMPOSITE BEAM

 EXTRA DATA SKIPPED ON TEST FILE        NG=  462 NT=  459
 T= USE COMMAND MACRO QAEND
 END OF SKIPPED DATA                    NG=  462 NT=  463

 BOTTOM OF GOOD FILE REACHED AT LINE    469
 G= |                            ANSYS RUN COMPLETED                            |


 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 NOTE- NONSTANDARD COMPARE - DIFOPT NAME QA70-1   HAS BEEN USED
 NUMBER OF LINES SKIPPED IN GOOD FILE(BLANK LINES EXCLUDED) -     1
 NUMBER OF LINES SKIPPED IN TEST FILE(BLANK LINES EXCLUDED) -     1
 NUMBER OF LINES ON GOOD FILE WITH STRINGS CONDENSED OUT    -     0
 NUMBER OF LINES ON TEST FILE WITH STRINGS CONDENSED OUT    -     0
 ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

 ************************************************
 COMPARE ERRORS =       1                       *
 ************************************************


 ================================================================================
  PROBLEM: inrt-16s         COMPARE OPTIONS  COMPARE_REL 3.8 UP20020121   WINDOWS

 ALMOST ZERO (GOOD)   = 1.0000E-006            KROUND (DROP LAST DIGIT)=   1
 ALMOST ZERO (TEST)   = 1.0000E-006            KABSPR (0=SUMMARY 1=ALL)=   1
 ABSOLUTE VALUE TOL   = 1.0000E-010            KSKIP(SKIP=ERR 0=Y, 1=N)=   0
 FRACTIONAL DIFFERENCE= 1.0000E-004            MAXERR (STOP WHEN ERRS )= 100
 ABSOLUTE DIFFERENCE  = 1.0000E-006            MAXBUF (# LINES TO SCAN)=   6
                                               KNOWN  (# OF KNOWN ERRS)=   0
                                               GREAD, TREAD =    1,   1
 ================================================================================

 LINES ON GOOD FILE =      484
 LINES ON TEST FILE =      486
 ******************************************************************************
```

Appendix G

Waste Level and Specific Gravity Investigation

G.1 Introduction

The baseline analysis of the DSTs, exclusive of the AP tank farm, was performed using a nominal waste height of 422 inches and a waste specific gravity (SpG) of 1.7. These values represent upper bounds of expected values. The purpose of this appendix is to quantify the change in the demands on the anchor bolts and primary tank if the waste height and waste SpG are less than the nominal values used in the baseline analysis.

The configuration selected for analysis was a waste height of 360 inches and a waste SpG of 1.4. Tank waste measurements have demonstrated a solid-like layer of waste (sludge) on the bottom of the tank with a liquid layer on top. The waste configuration of interest is 1/2 sludge with a SpG of 1.7 and 1/2 liquid with a SpG of 1.1. This results in an average waste SpG of 1.4. Because this is a sensitivity study rather than an analysis of record, only the single case of best-estimate soil (BES)-best-estimate concrete (BEC)-lower-bound secant stiffness (LBSS) was considered.

G.2 TOLA Model

Complete documentation of the TOLA model is found in (Rinker et al. 2004). The current model is identical to the previous model except for waste configurations. Figure G.1 shows the previous and current DST models with the respective waste heights and SpG's. For the initial comparison purposes, an analysis was completed with 422 inches of waste at the design-basis waste temperature of 350ºF, identical to the baseline analysis. Subsequent analysis was conducted with 360 inches of 1/2 sludge – 1/2 liquid waste at a temperature of 160ºF. This provided consistency with the analyses reported in Section 6.6 of the main body of this report. These results were combined with the seismic results and are reported in Section G.6.

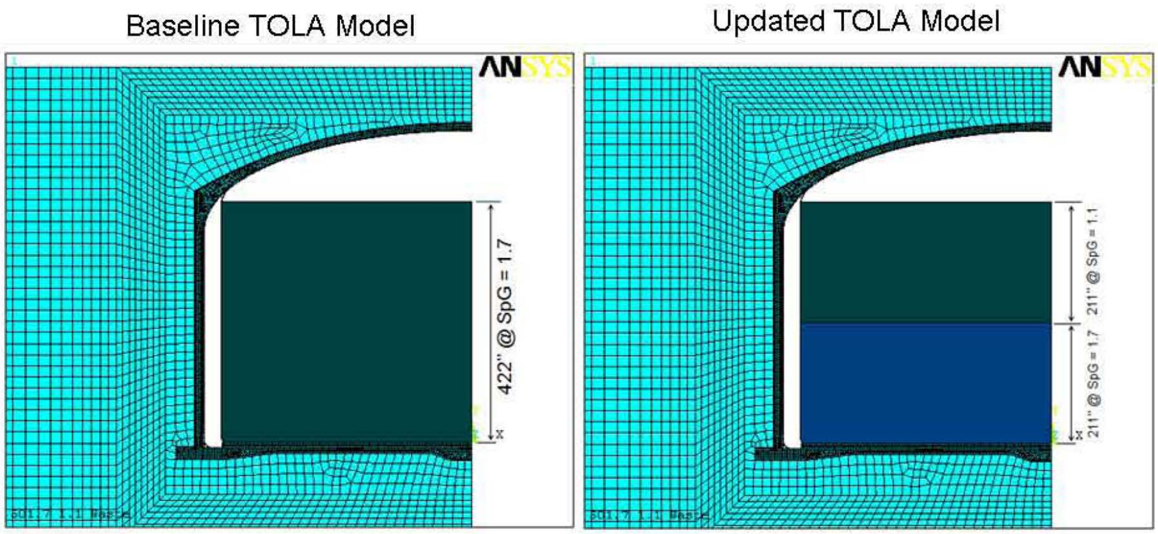

Figure G.1 TOLA model showing the waste heights and SpG's

G.3 Seismic Model

Although a waste height of 360 inches was selected for the TOLA evaluation, the closest nodal elevations in the waste for the seismic model were 345 inches and 373 inches. The lower value of 345 inches was selected for the seismic evaluation. If it is assumed that the impulsive frequencies of the baseline configuration (f_{i422}) and the new configuration (f_{i345}) are inversely proportional to the square root of the waste mass (as would be the case for a single-degree-of-freedom oscillator), an estimate of the increase in the impulsive frequency associated with the new configuration is given by the square root of the ratio of the original waste mass to the reduced waste mass. That is,

$$\frac{f_{i345}}{f_{i422}} \simeq \sqrt{\frac{(h_{422})(\gamma_{422})}{(h_{345})(\gamma_{345})}} = \sqrt{\frac{(422)(1.7)}{(345)(1.4)}} = 1.22$$

If the impulsive frequency for the baseline system is approximately 7 Hz, which is representative of that configuration, the impulsive frequency shift is expected to be approximately 1.5 Hz. That is, the impulsive frequency shift is large enough to be associated with significant changes in the spectral acceleration for the dominant impulsive mode, and potentially, significant changes in the system critical responses.

The seismic model used in this evaluation is a slight modification of the model used for the baseline analysis that is reported in Rinker and Abatt (2008). The height of the waste was reduced by unselecting the waste elements above the height of 345 inches. A plot of the primary tank and waste is shown in Figure G.2. As a comparison, a plot of the baseline model with a waste height of 422 inches is shown in Figure G.3.

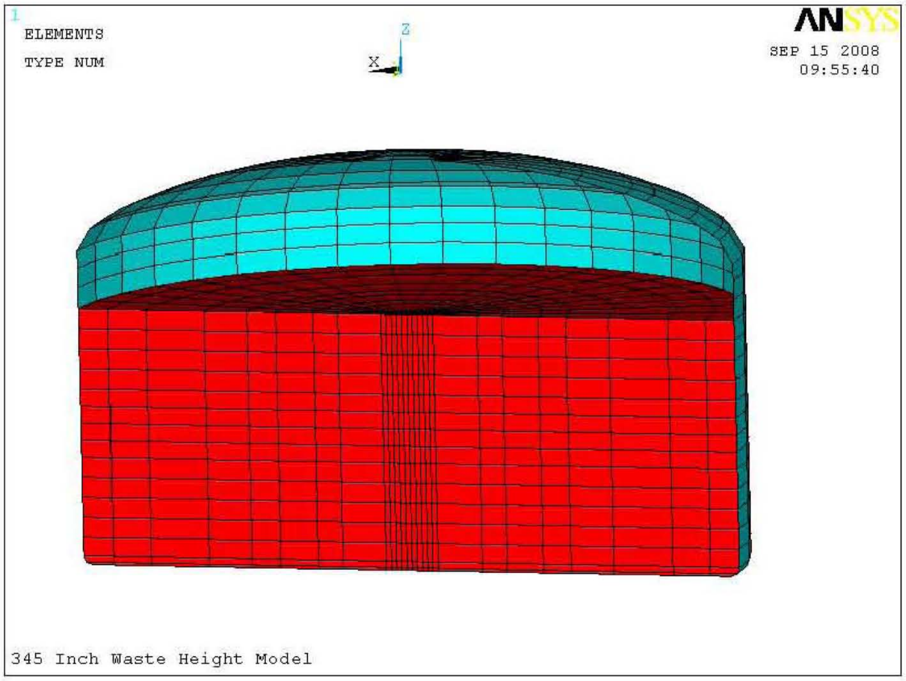

Figure G.2. Primary Tank Seismic Model with 345 Inch Waste Height.

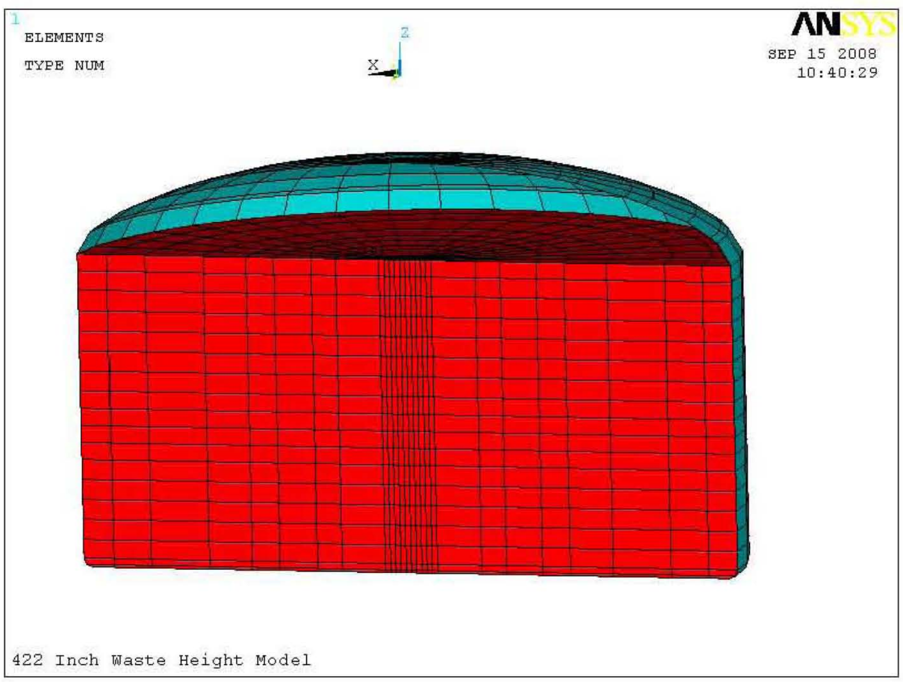

Figure G.3. Primary Tank Seismic Model with 422 Inch Waste Height (Baseline Configuration).

G.4 TOLA Results

Through the course of the recent DST structural integrity analyses, the primary tank and anchor bolt evaluations have been of the most interest. Accordingly, results for these two evaluations are presented in the following sections.

The primary tank membrane stress intensity comparison is shown in Figure G.4. The stress decreases with the reduction in waste mass.

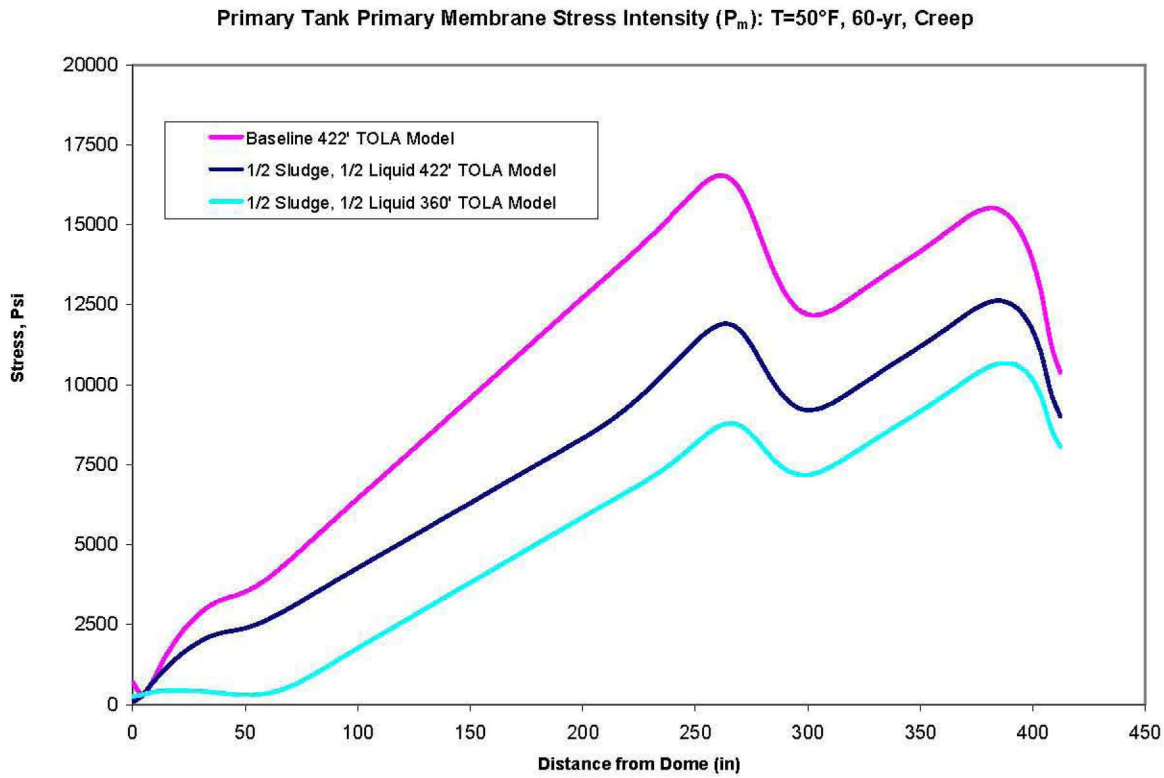

Figure G.4. Primary Tank Membrane Stress Intensity

The anchor bolt evaluation considers both the axial and shear demands. However, the shear component is the predominant factor. Therefore, Figures G.5 and G.6 present the anchor shear demands at 160ºF and 80ºF respectively. In contrast to the primary tank stress, the anchor bolt demand is seen to be largely insensitive to the waste mass.

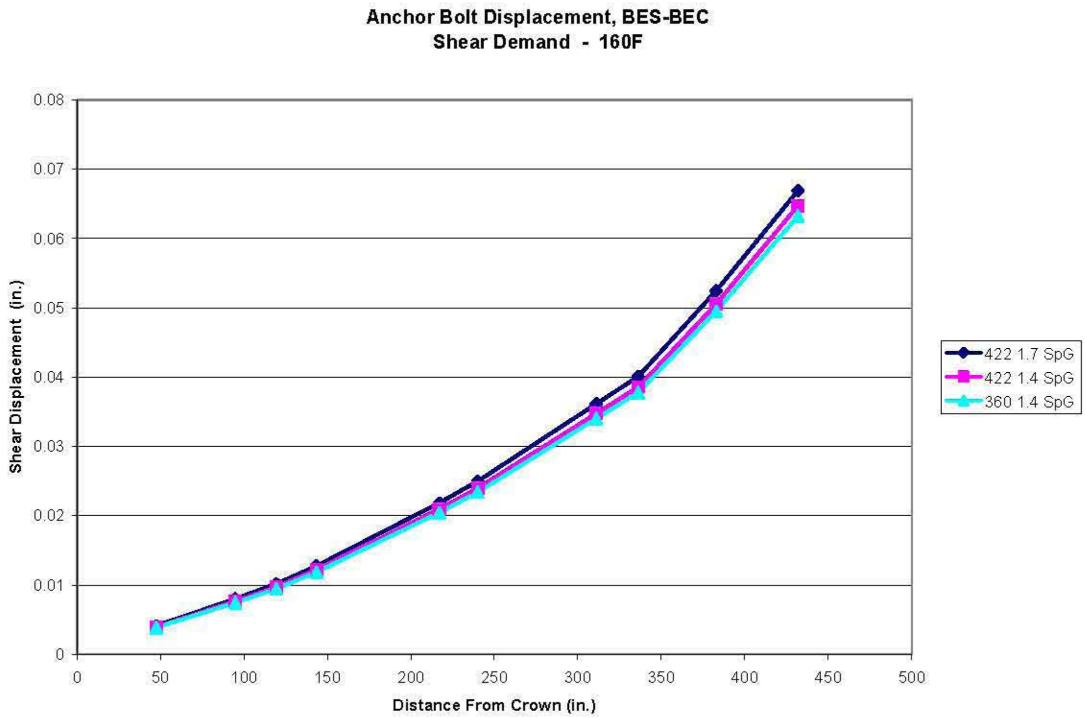

Figure G.5. Anchor Bolt Shear Demand - 160ºF

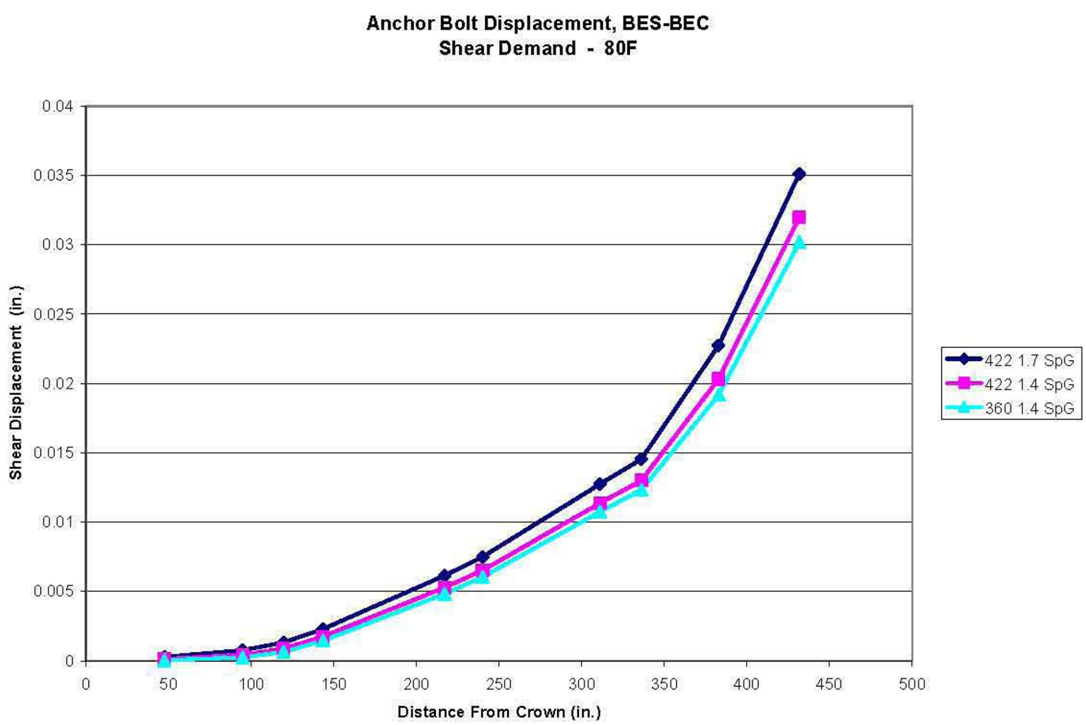

Figure G.6. Anchor Bolt Shear Demand - 80ºF

G.5 Seismic Results

Figure G.7 through Figure G.13 compares the maximum stresses in the primary tank for the baseline and reduced waste level cases. Each plot shows maximum stress as a function of path length, with the path length beginning at the dome apex.

The in-plane shear stress at the mid-wall of the primary tank is shown as Figure G.7. The overall in-plane shear stress is low, and the reduced waste level case tends to be lower than the baseline case.

Figure G.8, Figure G.9, and Figure G.10 show the maximum hoop stress in the primary tank at the outside, mid, and inside surfaces of the primary tank, respectively. In each case, the stress in the reduced waste level case is effectively the same as, or less than for the baseline case.

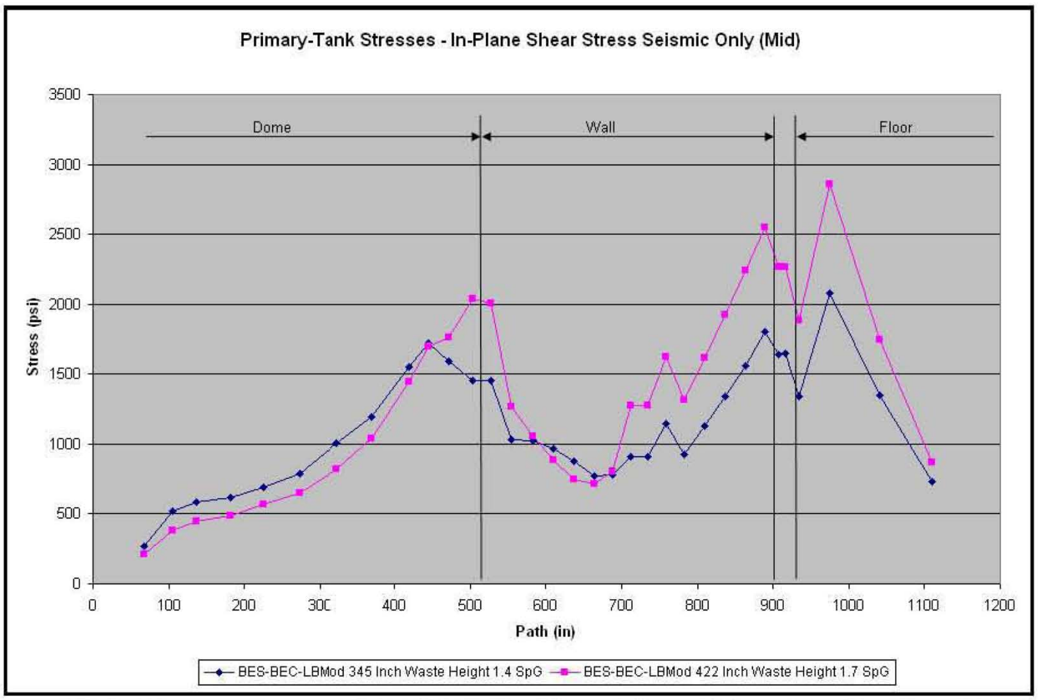

Figure G.7. Comparison of Mid-Wall In-Plane Shear Stress for the Baseline and Reduced Waste Level Cases.

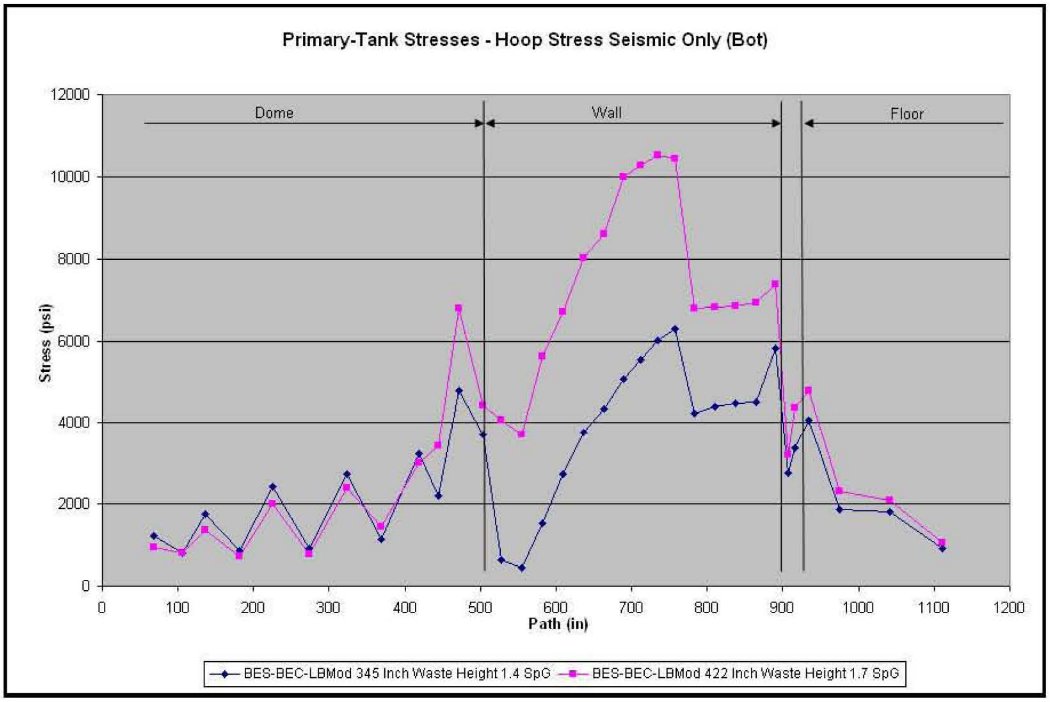

Figure G.8. Comparison of Hoop Stress on the Outside Surface of the Primary Tank for the Baseline and Reduced Waste Level Cases.

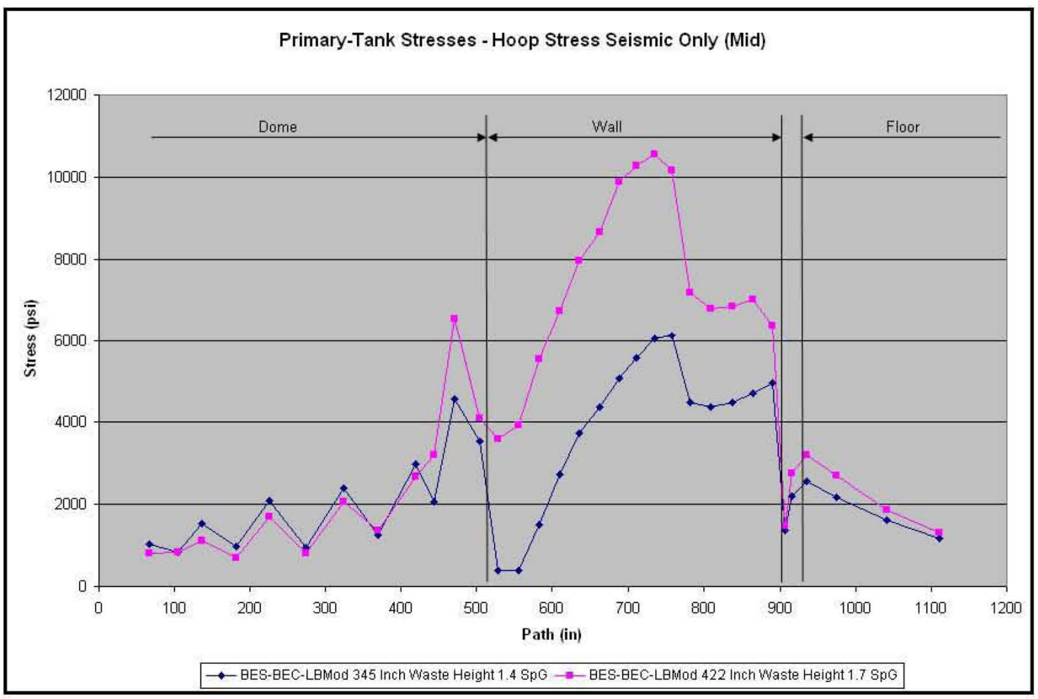

Figure G.9. Comparison of Hoop Stress at the Mid-Surface of the Primary Tank for the Baseline and Reduced Waste Level Cases.

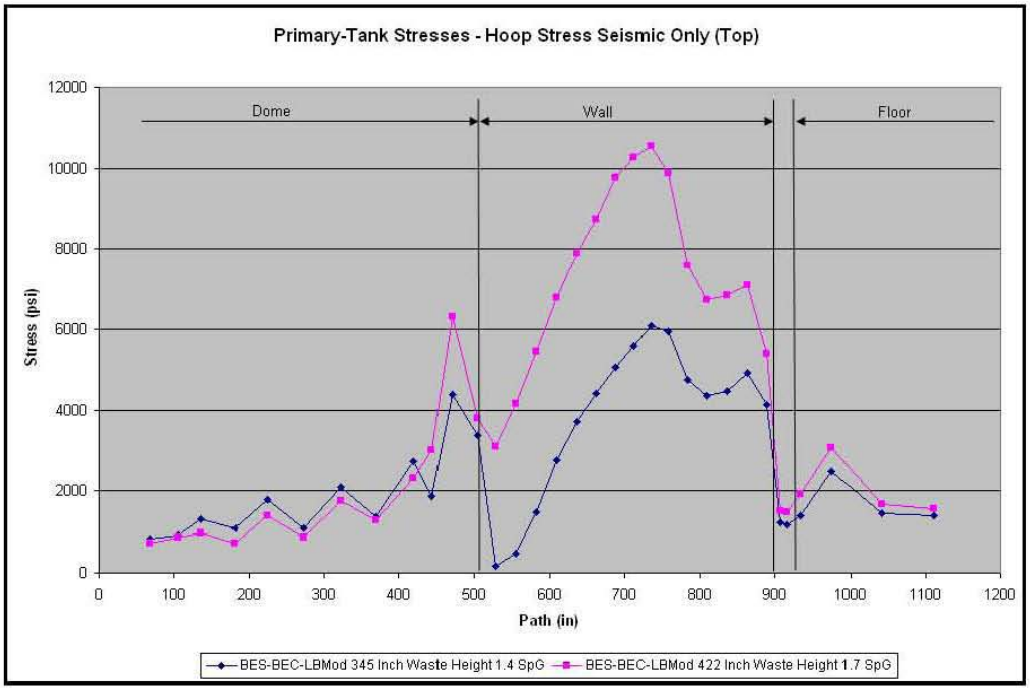

Figure G.10. Comparison of Hoop Stress on the Inside Surface of the Primary Tank for the Baseline and Reduced Waste Level Cases.

Figure G.11, Figure G.12, and Figure G.13 show the maximum meridional stress in the primary tank at the outside, mid, and inside surfaces of the primary tank, respectively. In each case, the stress in the reduced waste level case is effectively the same as, or less than for the baseline case.

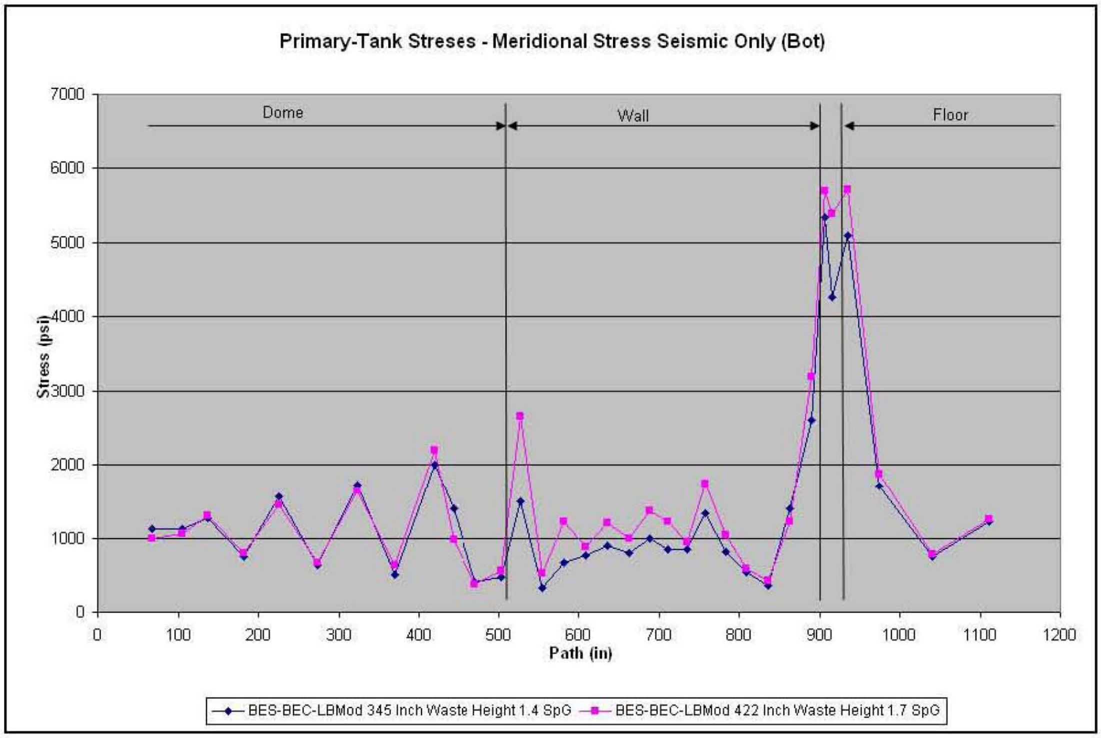

Figure G.11. Comparison of Meridional Stress at the Mid-Surface of the Primary Tank for the Baseline and Reduced Waste Level Cases.

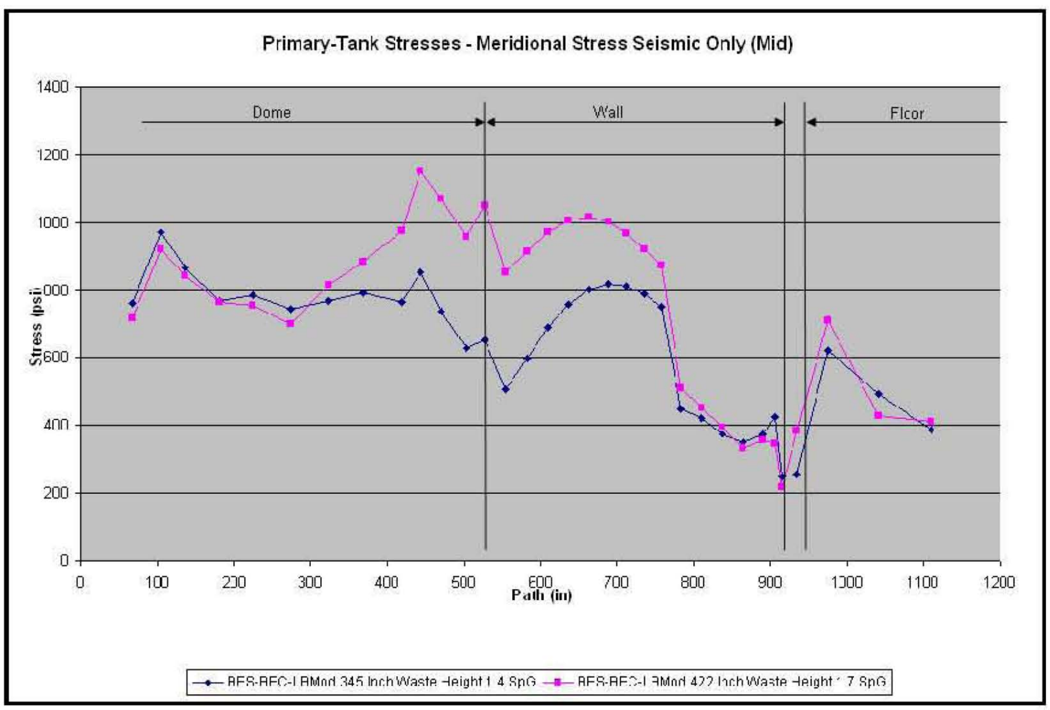

Figure G.12. Comparison of Meridional Stress at the Mid-Surface of the Primary Tank for the Baseline and Reduced Waste Level Cases.

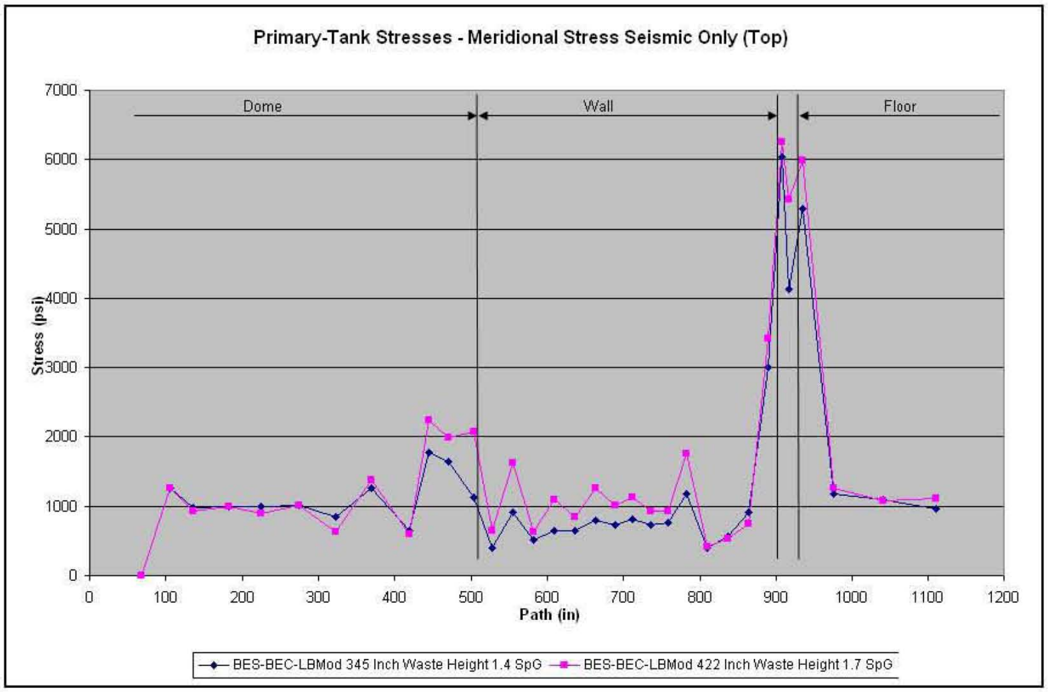

Figure G.13. Comparison of Meridional Stress on the Inside Surface of the Primary Tank for the Baseline and Reduced Waste Level Cases.

The first two curves in Figure G.14 represent the shear displacements in the anchor bolts as a function of distance from the dome apex for seismic loading only. These two curves are in terms of the shear displacement axis on the left of the plot. The third curve shows the ratio of the anchor bolt shear displacements for the new and baseline configurations and is referenced to the secondary vertical axis on the right hand side of the plot. This plot shows that the shear displacements for the new configuration vary between approximately 55% and 70% of the baseline shear displacements. The fourth curve represents the constant waste mass ratio of 0.67 for the two configurations, and it is also referenced to the secondary vertical axis on the right of the plot. The intent of the third and fourth curves is to illustrate that the reduction of anchor demands under seismic loading for the new configuration corresponds fairly closely to the reduction of waste mass.

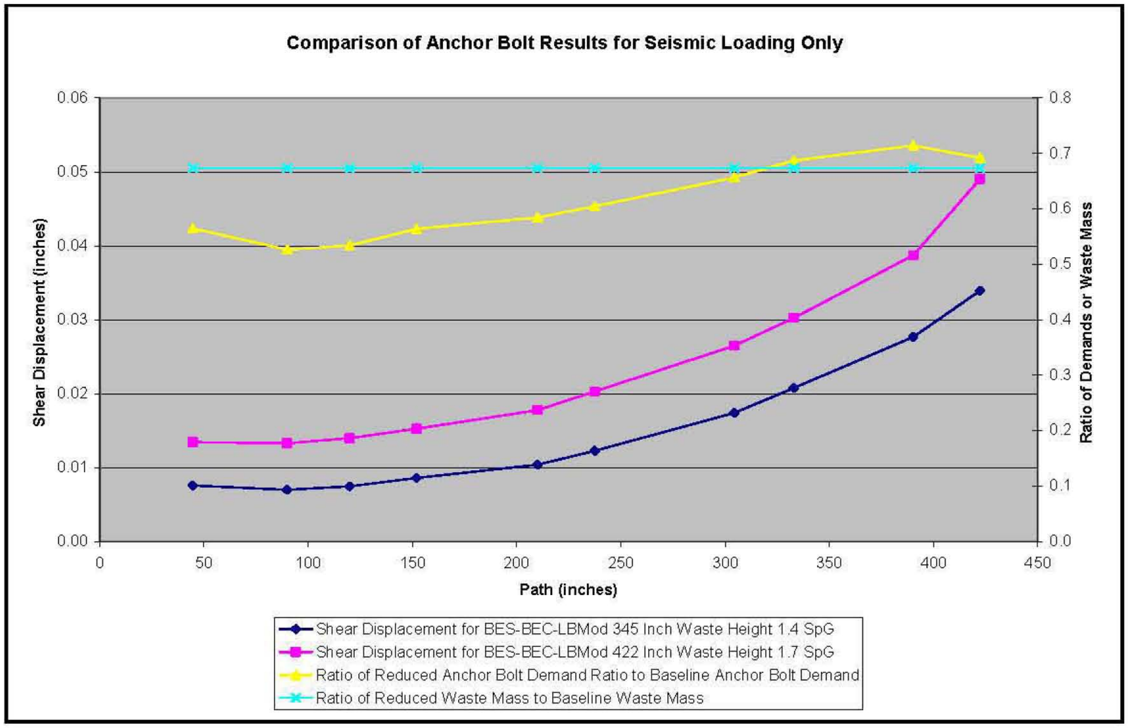

Figure G.14. Comparison of Anchor Bolt Results for the Baseline and Reduced Waste Level Cases.

G.6 Combined Results

The results from the 360 inch 1/2 sludge – 1/2 liquid waste TOLA analysis were combined with the 345 inch 1.4 SpG seismic analysis. As noted in the Introduction, this does not constitute an analysis of record, but does provide a degree of confidence in the tank structural integrity under the revised waste level and SpG.

The primary tank membrane stress intensity comparison is shown in Figure G.15. The stress decreases with the reduction in waste mass.

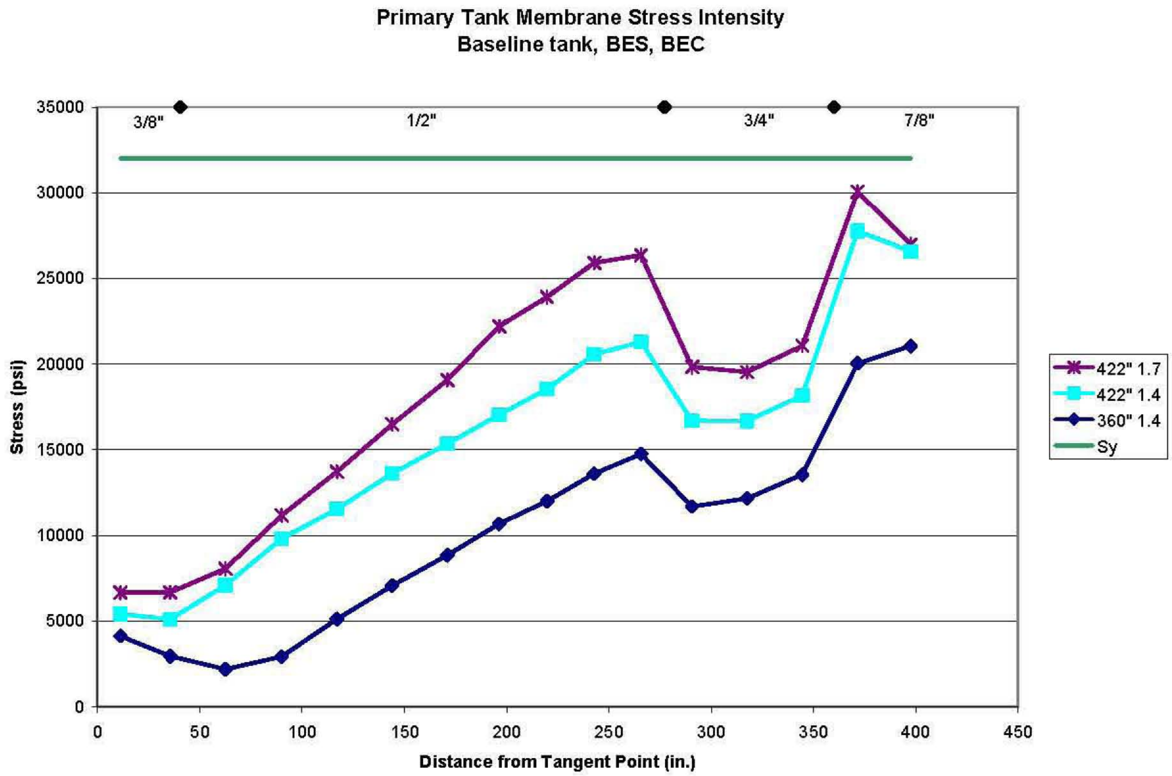

Figure G.15. Primary Tank Membrane Stress Intensity

The anchor bolt comparison at 160°F waste temperature is shown in Figure G.16. The insignificant change with the decrease in waste height is not unexpected given the flexibility of the upper knuckle and the distance to the dome. Similar results for the 80°F waste temperature are shown in Figure G.17.

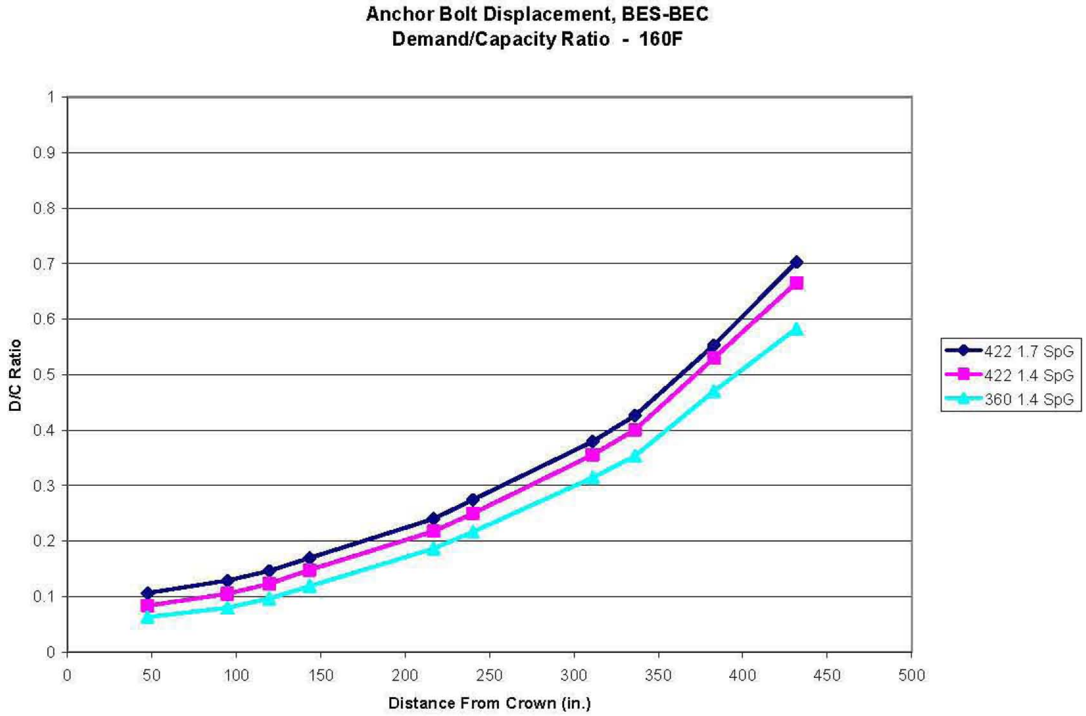

Figure G.16. Anchor Bolt Comparison - 160°F

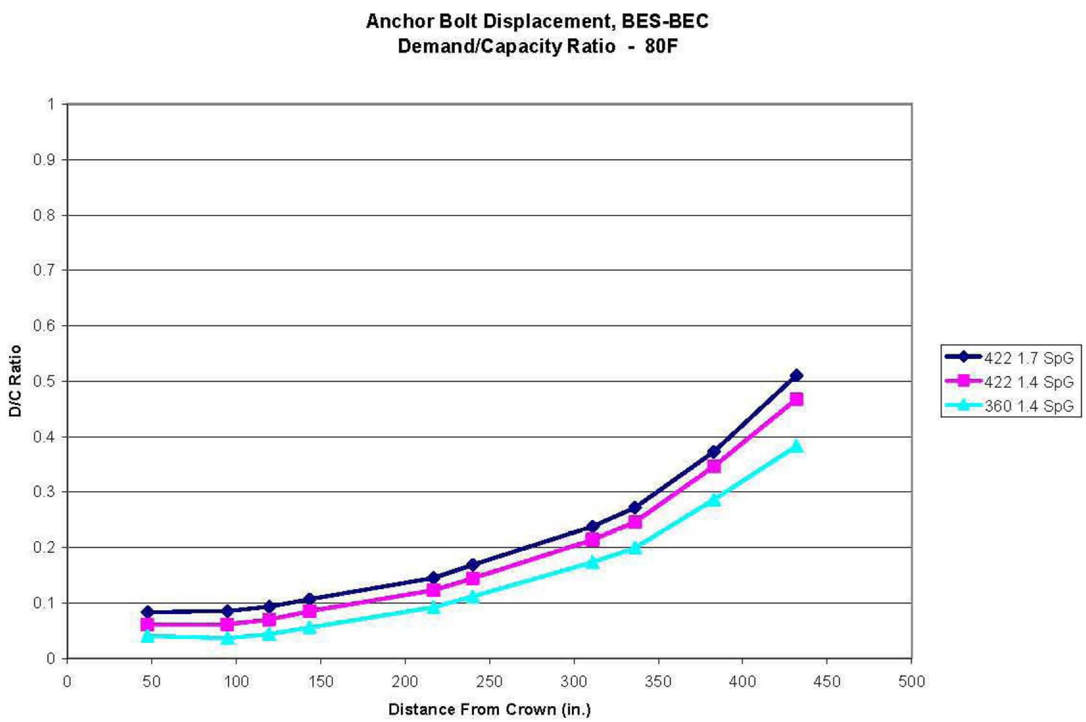

Figure G.17. Anchor Bolt Comparison - 80°F

G.7 Conclusions

The primary tank stress decreases with a reduction in waste mass. Therefore any reduction in waste mass through either changes in specific gravity or waste depth will result in lower stress. The anchor bolt demands also decrease with a reduction in waste mass. This is due largely to the dependence of the seismic anchor demands on the waste mass, as the non-seismic demands are largely independent of waste mass.

G.8 References

Rinker, M.W. and F.G. Abatt, 2008, *ANSYS® Seismic Analysis of Hanford Double Shell Tank*. RPP-RPT-28966, Rev. 1, prepared by M&D Professional Services, Inc. for Pacific Northwest National Laboratory, Richland, Washington.

Rinker, MW, JE Deibler, KI Johnson, SP Pilli, CE Guzman-Leong, and OD Mullen. 2004. *Hanford Double-Shell Tank Thermal and Seismic Project – Thermal and Operating Load Analysis*. RPP-RPT-23308, Rev. 0. Pacific Northwest National Laboratory, Richland, Washington